PRODUCT ENGINEERING

OCTOBER, 1947

THIS ISSUE — Supersonic Testing + Patent Protection + Silver Brazing of Cast [illegible] + Nonmetallic Ducts + Dielectric Heating + Fatigue Strength of Parts

A McGRAW-HILL PUBLICATION

11 YEARS IN SALT WATER

THE WELDED SPECIMEN, on the right, was part of a model gasoline tank designed for use with salt water ballast. Partially immersed for 4½ years in the polluted harbor at Newport News, Va., it was tested along with several other materials, and proved outstanding among the few that withstood this exposure without appreciable damage. After the Newport News tests, this specimen was continuously exposed for another 6 years, partially immersed in flowing sea water at Kure Beach, North Carolina.

Its companion specimen, made of the same alloy containing 70 per cent copper and 30 per cent Nickel, was similarly exposed at Kure Beach for 11 years. The rate of corrosion was the same for both specimens . . . only 0.0002" per year. These specimens are permanently displayed in the Inco Marine Test Station at Kure Beach.

Exposed to sea water for more than a decade, these two specimens show the remarkable corrosion-resistance of both welded and unwelded 70-30 cupro-Nickel alloy.

Welds . . . including butt, fillet and tack welds . . . performed as well as the rest of the alloy, reflecting its natural weldability and inherent corrosion resistance.

Although primarily developed for use in marine condenser tubes, this alloy is particularly useful for large diameter piping, water boxes, tanks, sheathing and similar forms.

It is strong, tough, and not susceptible to dezincification nor subject to stress corrosion cracking. It sturdily resists both pitting and erosion (impingement attack).

Full information is available upon request and we invite your inquiries.

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PRODUCT ENGINEERING

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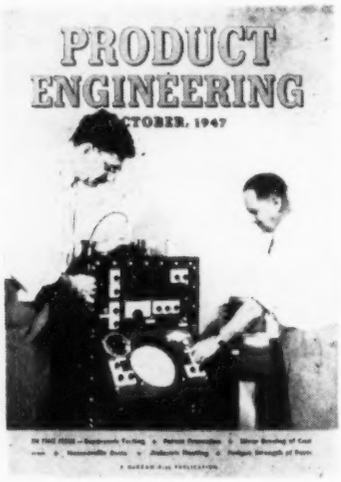

FRONT COVER

SUPERSONIC WAVE PULSES from this machine detect and locate flaws within parts made from metals, plastics and other materials; see page 113. Kodachrome taken in Laboratory of Sperry Products, Inc. by McGraw-Hill Photo Service.

Supersonic Inspection of Materials

Nondestructive tests are always useful in manufacture and design. A comparatively new technique that applies to both metallic and non-metallic materials, is the use of supersonic waves for inspection. On page 113, Benson Carlin, product engineer, Sperry Products, Inc., discusses the characteristics of supersonic waves and their use in locating minute flaws in various materials.

Protecting Product Designs

As far back as 1842, Congress recognized that an incentive should be given to the industrial designer in the form of the "design patent," to protect design as well as mechanical features of a product. On page 81, William K. Rieber, patent engineer, claims that design patents are not being used often enough by industry, and explains their functions and requirements.

Charpy and Izod Testing

Although Charpy and Izod impact tests are not new, they are still the subject of extensive investigation by metallurgists, physicists, and design engineers. Generally, the use of these tests for specification has lagged behind technical knowledge, probably as a result of the difficulty of interpreting these tests. On page 106, C. M. Schwitter, formerly Major, U. S. Army Ordnance Department, gives details of the various types of standard tests specimens and discusses the need for impact tests.

Fatigue Strength of Steel Parts

The three principal variables that affect the fatigue strength of steel parts are hardness, surface finish and stress concentration inherent in the shape of the part. On page 144, Dr. Charles Lipson, consulting engineer and associate, The Detroit Testing Laboratory, and Philip O. Johnson, head of structures department, Fisher Body Division, General Motors Corporation, present design charts for evaluating the endurance limits of steel parts having a given hardness, surface finish and stress concentration factor.

Dielectric Heating

Many design advantages can often be attained by the use of various production modifications. A new technique that should be investigated for possible design economies is dielectric heating of materials. On page 158, B. E. Rector, electronic engineer, Westinghouse Electric Corporation, describes some basic factors to consider in determining whether dielectric heating is desirable and profitable.

Turbine Pumps

There is an excellent possibility that the turbine or peripheral pump may have many uses not yet recognized because its principles of operation are not generally understood. On page 163, Warren E. Wilson, director of research, Sundstrand Machine Tool Company, analyzes the flow of fluid through this type of pump and derives characteristic equations for delivery, power and efficiency.

Electrified Drives for Conveyors

Electrified units driving trolley conveyors are extremely useful in many industrial machines and processes. Beginning on page 84, Sidney Reibel, materials handling consultant, Albert Kahn Associated Architects and Engineers, discusses problems in applying constant and variable speed drives, protective devices and multiple units for sprocket and caterpillar drives.

Silver Brazing of Cast Iron

The simple grey iron casting has design limitations as a material and in complex structures that are difficult to core. Silver brazing cast iron offers a commercially practical way of expanding the application of iron castings. On page 128, Harold Frick, chief engineer of the Kolene Corporation, offers several stimulating ideas on the design possibilities resulting from silver brazing of cast iron.

Specifying Hydraulic Fluids

Proper operation of many industrial machines depends on the type of hydraulic fluid used. On page 122, E. A. Reehl, Works Laboratory, General Electric Company, tells how to specify hydraulic fluids, and discusses seven basic factors, including viscosity, acidity, and load-carrying capacity.

Nonmetallic Air Ducts

Development of air ducts of nonmetallic materials was accelerated by the shortage of metals during the war. On page 138, the advantages of these new ducts are discussed in an article by Watson G. Harding, U. S. Rubber Company.

NOVEMBER HIGHLIGHTS

Small Zinc Alloy Die Castings, by Joseph Saks, Gries Reproducer Corporation. Engineering design data for specifying zinc alloy die castings weighing less than ½ oz., which are typical examples of economical parts that are usually sand cast, cold forged or wire formed.

Spot-welded Aluminum Lap Joints, by R. C. McMaster and H. J. Grover, Battelle Memorial Institute. Results of fatigue tests on spot-welded lap joints loaded in shear.

Industrial Adhesives, by Nicholas J. DeIollis, National Bureau of Standards. First of a two-part series, covering vegetable, protein and thermoplastic resin types of adhesives, and factors affecting bond strength.

High Heat and Corrosion Resistant Plastic, by E. B. Yelton, E. I. duPont de Nemours & Company. Properties and applications of this new thermoplastic, called Teflon, which has many uses as gaskets, seals and electrical components.

PRODUCT ENGINEERING Editorial

OCTOBER, 1947

The Buncombe About Engineers and Politics

A POPULAR SUBJECT for commencement speakers at technical university graduation exercises is the dearth of engineers in political offices. From many quarters comes the cry for the engineers and scientists to get into politics to save civilization from destruction by the discoveries and developments of the war years. The professional politicians smile. Well do they know that engineering is not politics; that today most of the pressing national problems are handled on the basis of political expediency rather than scientific deduction; that most voters cast their ballot for the candidate who promises most and is able to hand out the greatest amount of patronage. It sometimes makes little difference whether the candidate is a highly respected churchman or a jail bird. If he is sufficiently skillful in repartee, graft and largesse, he will be elected, even though he may be sentenced to serve his term of office in jail.

Formerly, unhealthy political conditions were confined to municipalities, cities and counties. They have now become national and even international. Increased participation of engineers in politics and public affairs will not improve matters basically. Only a complete national reformation and the general public adherence to a high code of morals can take us off the road to destruction. As long as the public condones dishonesty, deception and graft in public office, conditions cannot improve.

Not until we have a genuine reformation will it be possible to attract more qualified and specially trained men to high public offices to replace ward heelers and opportunists. We also must have more trained career men in statesmanship to meet the growing and pressing needs created by international situations.

Yes! All engineers should take active interest in politics. So should doctors, teachers, butchers, bakers and candlestick makers. But the crux of the whole problem is not a question of politics. It is a matter of the public demanding high moral standards, proper qualifications and necessary training of the candidates who will receive their vote. Obviously such a condition cannot come about until there has been a spiritual reawakening.

It is high time to debunk the loose accusations, by men who ought to know better, that engineers consider themselves "rough men in corduroy trousers," that they do not have interests beyond their profession, and that they shun politics. The answers are that no self respecting genuine engineer considers either himself or his associates as "rough men in corduroy trousers" and many engineers hold public office. As to blaming science and engineering for all the ills created by technological progress, it is sufficient to say that it is the responsibility of every individual to contribute to the improvement of conditions. The essential contribution, without which civilization is doomed, is a personal effort on the part of every individual to the establishment of a militant spiritual reawakening that will not tolerate scoundrels and incompetence in high places.

It is high time that the buncombe about engineers shirking their political responsibilities and wearing corduroy trousers be ended.

G. F. Nordenholt

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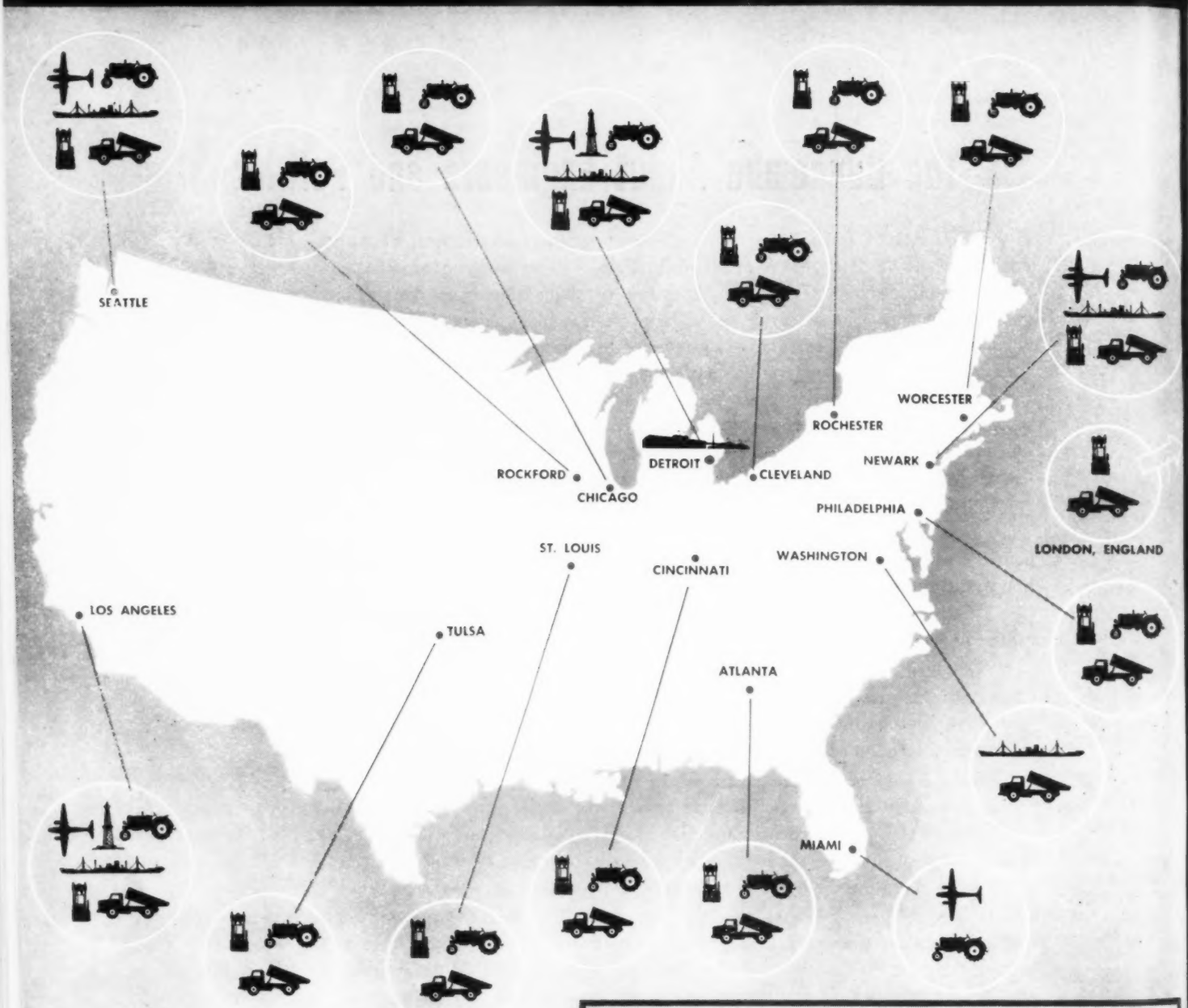

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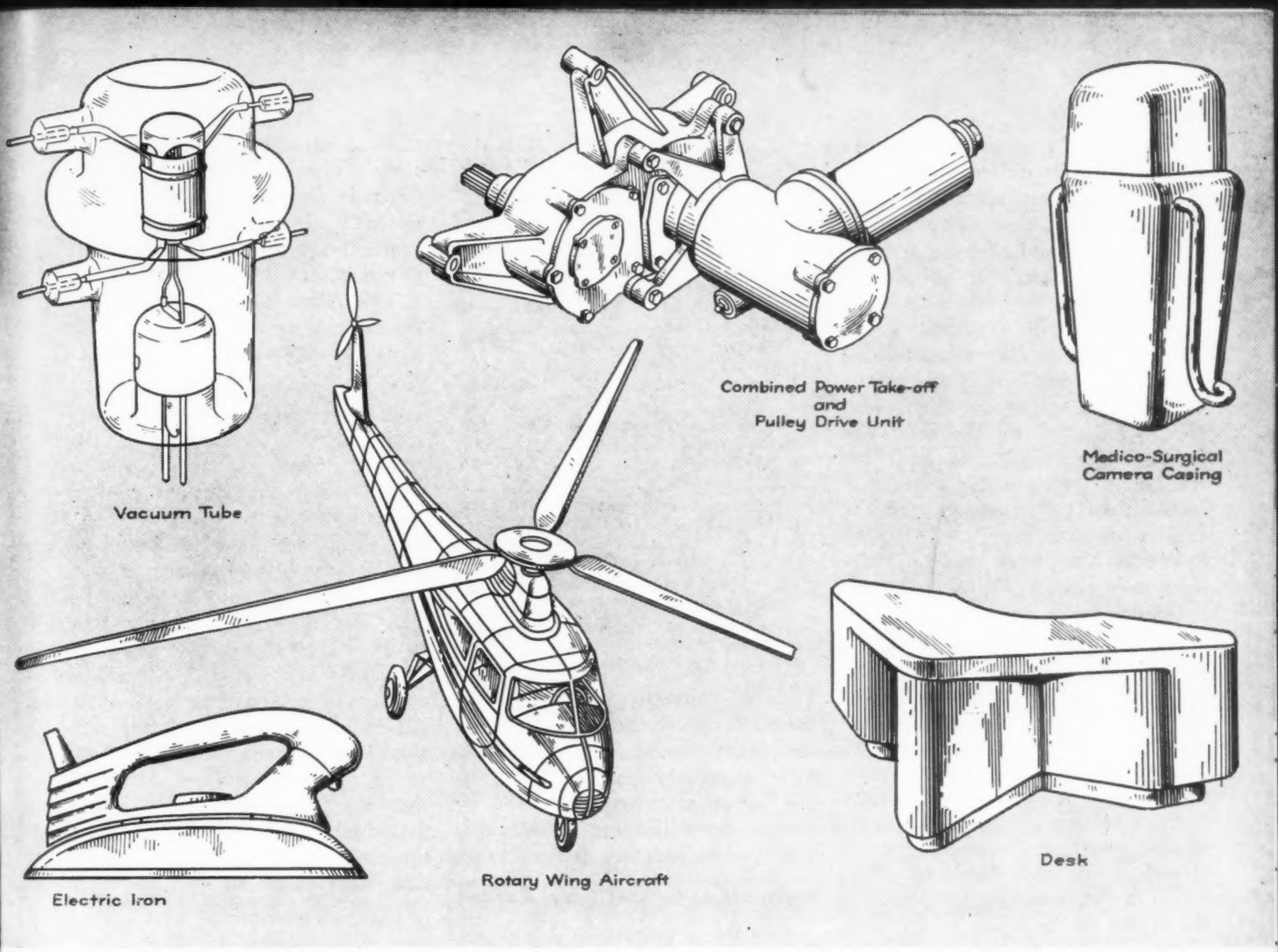
- MARINE

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921



Designs having their basic originality in their shape or ornamentation, or both, are recognized by the Patent Office.

DESIGN PATENT PROTECTION

WILLIAM K. RIEBER
Patent Engineer

Design patents, especially as they differ from mechanical patents, are defined. Their functions and method of preparation are explained.

DESIGN PATENTS have come to be regarded by many industrialists as a sort of "second line" defense—a type of protection to be had only if a mechanical patent is turned down by the Patent Office. This, however, was never their intended purpose. The original intention of Congress, in passing legislation providing for design patents, was to encourage "new and ornamental" designs for manufactured articles; a design patent covering such a design affords far better protection than could be given by a mechanical patent, a copyright, or a registered trademark.

Requirements for Design Patents

Another popular misconception regarding design patents is that they are granted only to protect decorative designs such as those on silverware, dresses, jewelry and the like. While it is true that such designs may be patented, almost any article can be the subject of a design patent, provided only that the statutory requirements of a patentable design are met. Briefly, these requirements are that the design be: (1) New, (2) ornamental (attractive), and (3) the product of invention. Thus, a great many products, the primary function of which is not decoration, have been subjects of design patents. Illustrated on this page are examples of such designs that have been patented.

Although the overall appearance

of a product, produced by the new design, must be different from anything in the "previous art," a novel and patentable design may often consist of a new and pleasing arrangement of old forms or old details. While attempts are frequently made, particularly by the examiners in the Patent Office, to take a new design apart and to analyze it element by element, the courts, with fair consistency adhered to the policy of judging patented designs from the standpoint of overall appearance rather than by an analysis of the various components.

We have said that patentable designs must be new. Who is then to judge whether a particular design is, or is not, new? This problem arises in cases involving infringement of a design patent, when it must be decided whether the allegedly infringing design does or does not produce the same overall appearance as the patented design. The prevalent attitude of the courts in answering the question of novelty in design is best expressed in the early landmark decision of the Supreme Court, in Gorham Vs. White (81 U. S. 511). This was a case of infringement in which the question of similarity of two silverware designs was involved. In the decision of the Court said:

> "We hold therefore that if in the eye of the ordinary observer giving such attention as a purchaser usually gives, the two designs are substantially the same, if the resemblance is such as to deceive such an observer inducing him to purchase one instead of the other, the first one patented is infringed by the other."

Although the silverware ornamentation which was the subject of the Gorham case would not be considered ordinarily as an "engineered" product, principles of the law apply as well to engineered products.

In the final styling of an article for presentation to the public, the functions of the engineer and designer must merge to produce a product which is both functionally perfect and attractive. The functional novelties can be protected by a mechanical patent and the design novelties by a design patent, which is not confined to purely ornamental objects. Patentable design invention was found in all these cases:

Coach Lamp—Britton v. White Mfg. Co., 61 Fed. 93.

Electric Heater—Majestic E. D Co. v. Westinghou e E. & M. Co., 276 Fed. 676, C.C.A. 9.

Radiator—Am. Radiator Co. v. Shirley R. & F. Co., 199 Fed. 424, C.C.A. 7.

Trailer and tow car and trailer combination—Harris & Schafer v. Curtiss Aerocar Co., 69 F. (2d) 264, C.C.A. 5 (1934).

Electric Sandwich Toaster Grill—Foretek Plating & Mfg. Co. v. Knapp-Monarch Co., 106 F. (2d) 554, C.C.A. 6 (1939).

Cloth measuring and computing machine—Grand Rapids Showcase Co. v. Measuregraph Co., 28 F. (2d) 497 C.C.A. 8 (1928).

Parking light for automobile—Gross v. Norris, 26 F. (2d) 898, C.C.A. 4 (1928).

Lens for stop signal—Protex Signal Co., v. Feninger, 11 F. (2d) 43, C.C.A. 6 (1926).

Arm for lighting fixtures—Shapiro & Aronson v. Franklin Brass Foundry, 272 Fed. 176, D.C.E.D. Pa. (1921).

Thus, "attractiveness" or "ornamental value" are not esoteric things, the presence or absence of which is to be decided by experts. The question of attractiveness is decided by the one most likely to be attracted, namely—the ordinary purchaser.

Designs Must Be Specifically Applied

A design is patentable only if applied to a manufactured article. This application of the design to a specific object can be considered the equivalent of "reduction to practice" in mechanical inventions. Accordingly, a mere abstract picture is not patentable as a design *per se*. Such a picture may, however, be protected by a copyright. Similarly, an identifying mark which does not appreciably alter the overall appearance but is merely used to identify the source of the goods is usually not patentable as a design but may be registerable as a trademark. A patented design may in some instances operate as a trademark in that it identifies the source of goods to which it is applied. An outstanding example of this for many years was the characteristic shape of the Packard automobile radiator.

Novelty in appearance brought about, for example, by the mere details of construction, is not in itself enough to warrant the granting of a design patent. There must be an apparent, conscious effort by the designer to make the article more artistic, more attractive, or more ornamental. Without the appearance of such an effort, the design is considered to be unpatentable for "lack of invention." The standards of the Patent Office in design cases have been considerably elevated of late by more frequent use of "lack of invention" as grounds for rejection.

The Patent Office and the courts recognize three general classes of designs. These are:

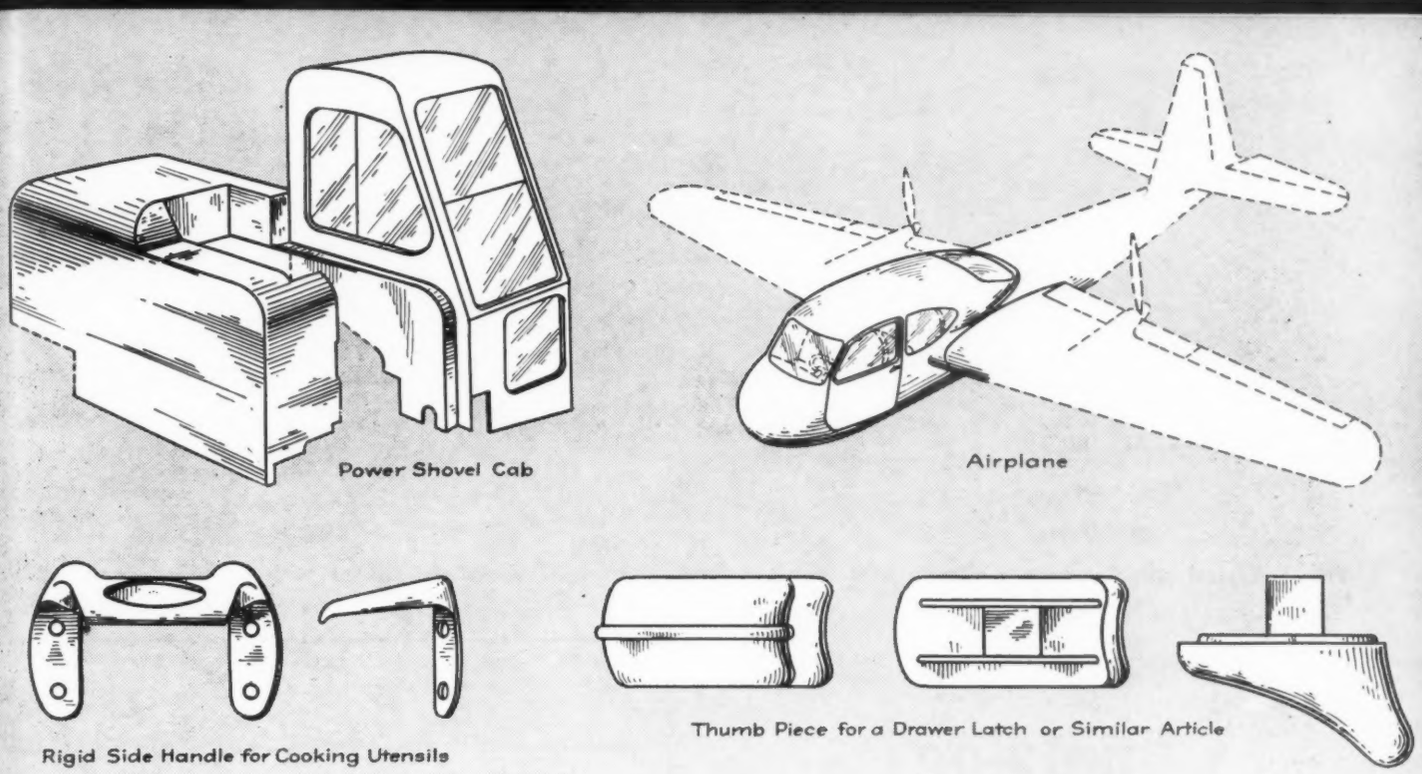
1. Designs involving ornamentation, such as a grill design for a radio cabinet, a printed fabric, or the pattern in a hand grip on a gun stock.
2. Designs which reside in shape or configuration of the article, such as kitchen utensil handles, machinery pedestals, tool handles, control handles and the like.
3. Designs which combine these two features—that is, where both the surface ornamentation and the shape combine to produce the overall effect. An example of this class is the exterior handle for an autobile door, which has a streamlined configuration plus surface ornamentation in the form of flow lines carrying out the motif expressed by the streamlined shape.

The manufacturer of an article is primarily interested in the scope of protection provided by design patents covering one or more of these design classes. This means: Who can he sue for infringement of his patents? Again we must turn to court decisions in infringement cases. In this regard the Gorham vs. White decision quoted previously has been closely followed. That is, if the ordinary purchaser (not the "expert") finds an article to be confusingly similar in appearance to a design-patented article, then the patent is infringed.

If a design combining several old elements relies heavily on one of them for its "new overall appearance" and hence its patentability, then a design which omits this one important feature does not infringe even though it may resemble many other elements of the patented design. This general rule was laid down in another landmark case, that of Smith v. Whitman Saddle Co. (148 U. S. 674).

Protecting a Line of Products

How can a manufacturer protect a complete line of products differing in size and possibly in shape, but all of the same general class, and ex-



When the shape of a part of a product is patented, it is shown alone, or the non-patented part is drawn in dotted lines.

pressing the same design motif? Examples of such "lines" are:

1. Hand tools having various sizes and shapes of work head, but having the same general shape of handles.
2. Silverware, such as knives, forks and spoons, all with the same type of handle.
3. Kitchen utensils having the same surface pattern but varying widely in size and shape.
4. Containers for cosmetics and other products which may be of various shapes and sizes best adapted for the material they contain but which express the same ornamental design.
5. Pedestals for machine tools.
6. Housings for certain types of meters and gauges such as flow meters, pressure gauges and thermometers.
7. Glass envelopes for various types of electronic tubes.

It would be extremely unfair to require the inventor or industrial designer to take out forty-eight separate design patents to protect a forty-eight piece set of wrenches. Yet if the rule stated earlier were strictly applied, a design patent on a 5/8 in. end wrench would not prevent another manufacturer from applying the new design, for example, to a 1 in. box wrench, since these two articles are not likely to be considered "confusingly similar."

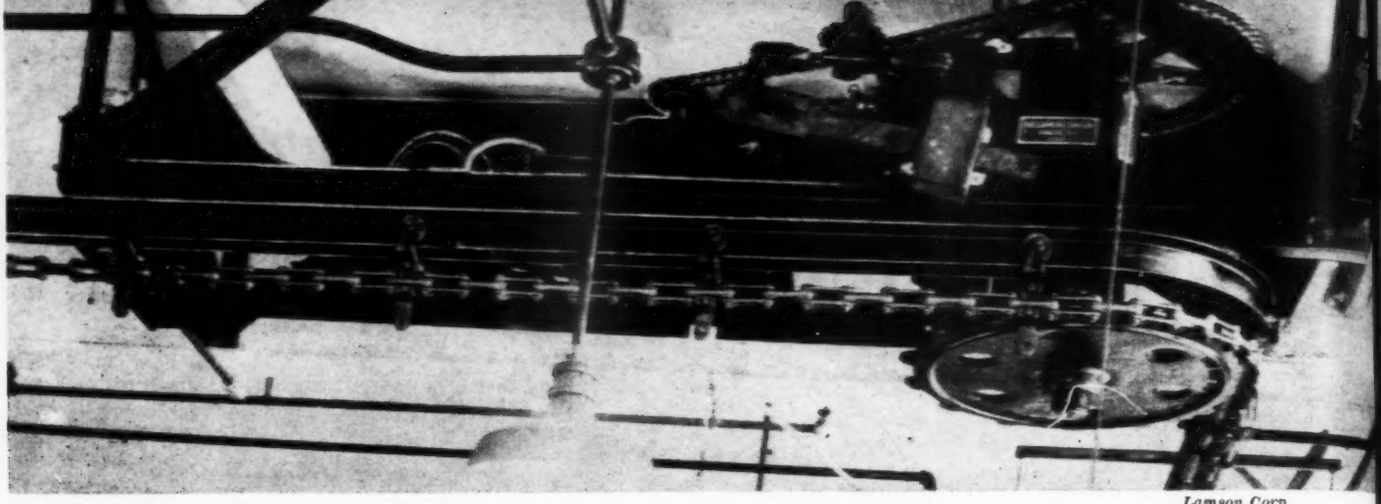
The answer to this apparent dilemma is that the patent does not protect the article itself, but the design as applied to the article. The design patentee is entitled to protection not only on the particular article he selects to illustrate his new design for the purpose of receiving a patent, but on all similar articles, providing the mode of applying the design is always essentially the same. For this reason, the claims of many design patents read "I claim the new and ornamental design for a ———— or similar article. . . ." The scope of such a patent is left in the hands of the Courts, which must decide whether an allegedly infringing design is applied to a "similar article" to that patented. As an example, a patent on the hand grip pattern on the gun stock mentioned previously might be infringed by the same design on a pistol grip electric drill. The radio grill design, if patented, might be infringed by a similar grill on a ventilator.

While surface ornamentation designs have considerable scope, the second and third classes listed—those involving shape or configuration or a combination of shape and surface pattern—afford somewhat less protection if patented. One exception to this statement can be found in the large number of design patents granted on silverware. Frequently the shape of the handle is shown in full line in the patent drawing while the functional part, such as the bowl of a spoon is shown in dotted lines to indicate that the new design resides in the shape of the handle and is thus applicable to various implements. Occasionally a design patent covers the design of a portion of an article (Fig. 5), such as a handle, which is shown entirely removed from the article.

Appearance Protection Important

The proper method of protecting a new industrial design can only be arrived at after careful consideration. The greatest value of a product in the "consumer goods" class usually lies not in its mechanical construction, which may be old, but in its appearance. Consequently, considerable expense is warranted in preserving the exclusive right to use this design and in getting protection before the production goes on the market.

Protection begins only when the patent issues. Even though the Patent Office is at present behind in its work, it is wiser to wait for a patent than it is to disclose a new design, and run the risk of competitors copying it.



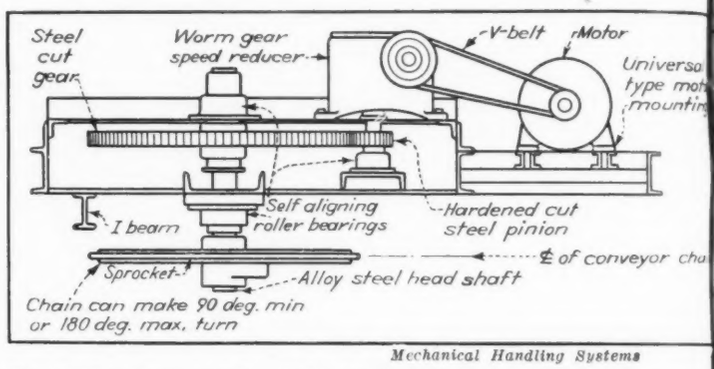
Lamson Corp.

Fig. 1—Typical sprocket type conveyor with torque control. Allowable chain pull varies with sprocket diameter.

Applying Electrified Drives To Conveyors

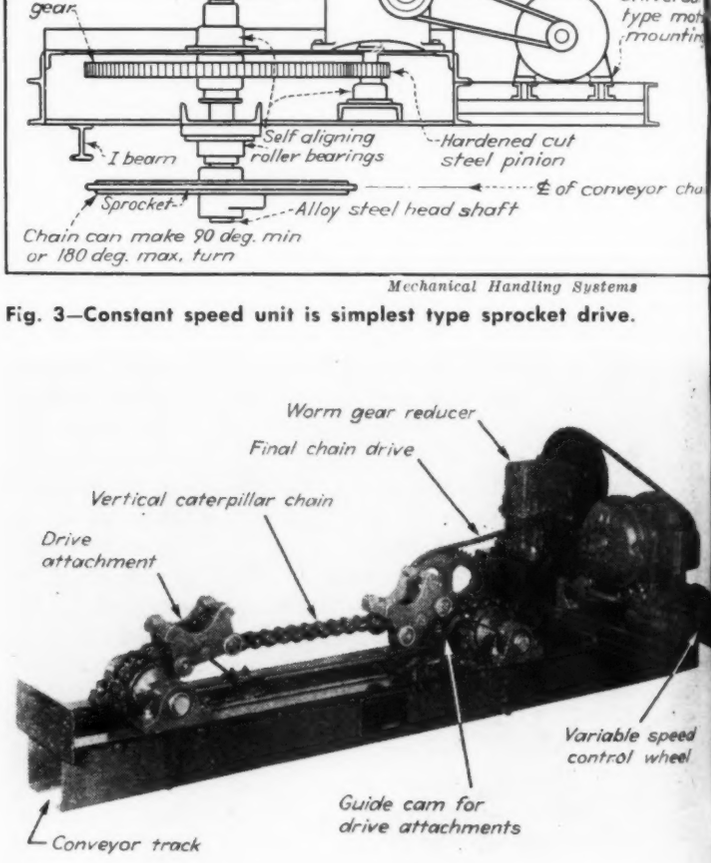
SIDNEY REIBEL
Consultant
Albert Kahn Associated Architects and Engineers, Inc.

Problems in applying sprocket and caterpillar drives to trolley conveyors for industrial machines or processes are explained and discussed. Constant and variable speed drives, three types of protective systems, multiple power units, direct current drives, and other data are included in the presentation.



Mechanical Handling Systems

Fig. 3—Constant speed unit is simplest type sprocket drive.



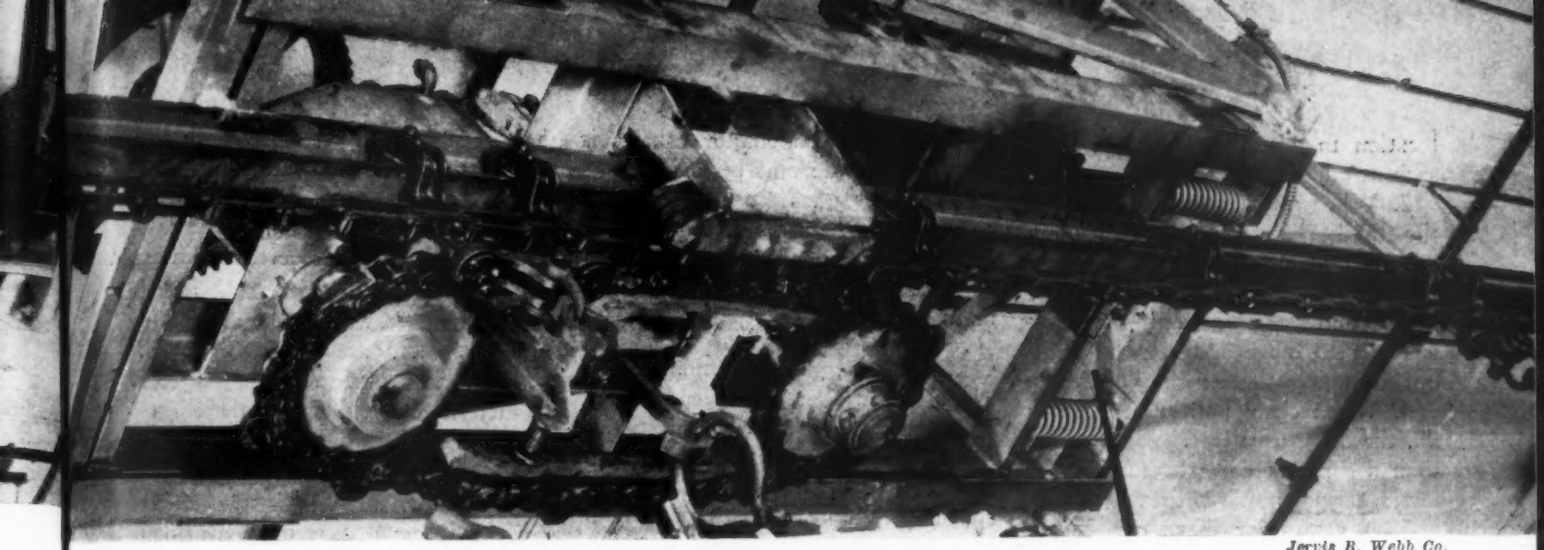
Taylor and Gaskin, Inc.

Fig. 6—Vertical caterpillar unit designed for special drive.

THE electrified unit driving a trolley conveyor for an industrial machine or process preferably is located on a high run, preceding a "down" dip, so the weight of the chain, trolleys, and carriers pulls the slack in the chain away from the unit. The part of the machine or building supporting the drive must sustain both the chain pull and the conveyor weight. Because head room usually is limited most drive units are long, low, and narrow to fit available space.

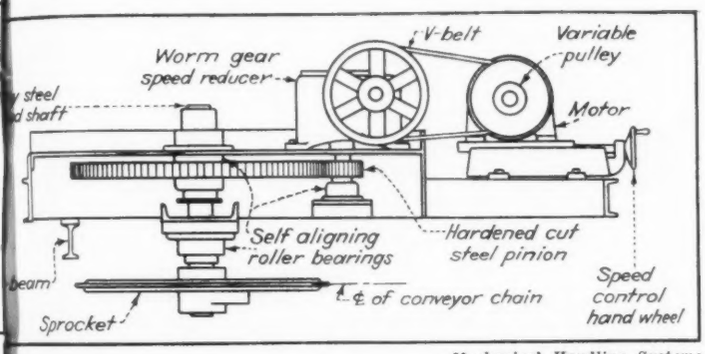
There are no general standards for trolley conveyor drives although the two general types are: Type *S* or sprocket drives; and Type *C*, or caterpillar drives. As shown in Figs. 1 and 2, the general arrangement of the drive machinery is the same for both types, but they engage the conveyor chain by quite different means.

SPROCKET DRIVES. A sprocket drive is placed at a 90 or 180 deg. corner turn, and the conveyor chain wrapped around the sprocket. The drive is rated for chain pull at the head sprocket. Ratings usually are on the basis of the commonly used 36 in. pitch diameter drive sprocket. Since these drives have a constant torque rating, the allowable chain pull for other than 36 in. sprockets is in-



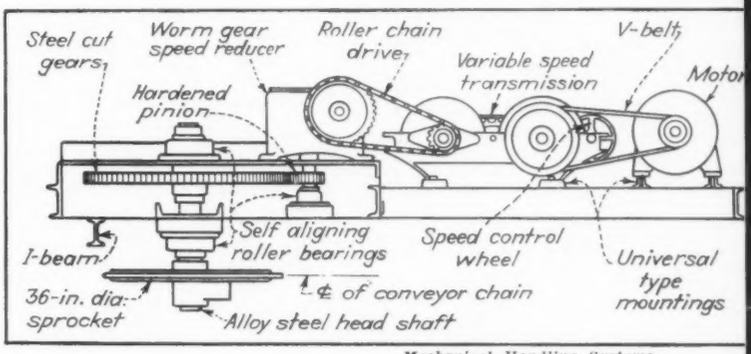
Jervis B. Webb Co.

Fig. 2—Typical caterpillar "floating" drive. Caterpillar drives are not limited by relative location nor angle of horizontal turns.



Mechanical Handling Systems

Fig. 4—Variable diameter pulley drive for 3 to 1 speed range.



Mechanical Handling Systems

Fig. 5—Full variable drive provides speed range of 10 to 1.

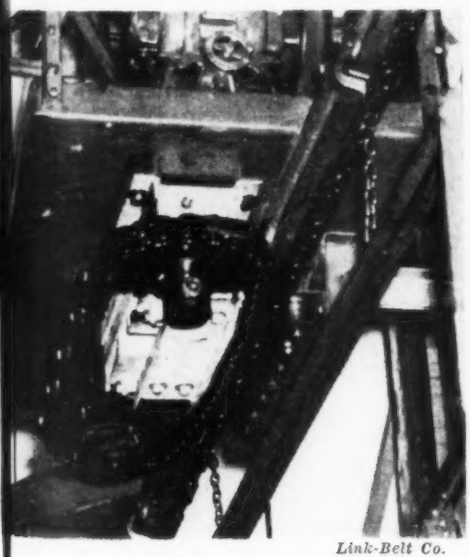


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Fig. 7—Caterpillar drive as booster.

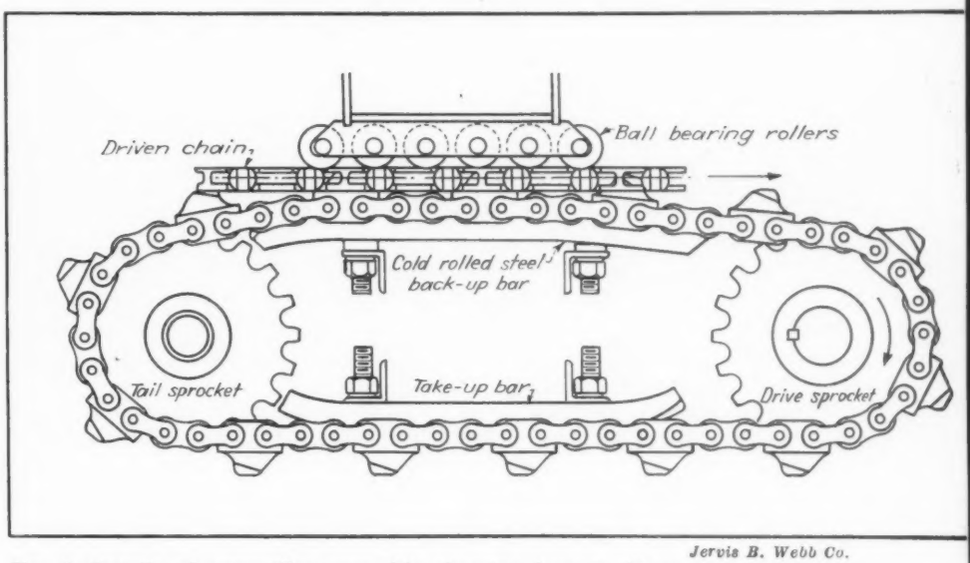

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Fig. 8—Details of caterpillar assembly showing how it drives conveyor chain.

versely proportional to the pitch diameters of the respective drives.

For example, the maximum allowable chain pull for a 48-in. sprocket is 36/48 or three-fourths that for a 36 in. sprocket. But when smaller sprocket is used with the same drive, the chain pull may be too great for the strength of the drive shaft. For example, a 12 in. sprocket would increase the allowable chain pull 300 percent. The different views in Figs. 3, 4, and 5 compare the basic types of sprocket drives.

CATERPILLAR DRIVES. The caterpillar drive uses a short loop of auxiliary drive alongside and parallel to the conveyor chain, and is placed on any straight run of conveyor, as shown in Figs. 6, 7, and 8. Driving dogs on the caterpillar chain engage and drive the conveyor chain. Back up bars or rollers on the caterpillar side, and rollers on the driven chain side, hold the two chains close together.

Caterpillar drives are rated for chain pull only, since only one size of drive sprocket is used for each type of conveyor chain.

Advantages of caterpillar drives include:

1. They can be placed in the best

location to take the chain pull load, such as middle of a straight run.

2. When multiple drives are used, the total chain pull can be more evenly divided.

3. If load conditions change or if the conveyor is altered, the drive is easier to move and relocate without changing the existing conveyor.

4. When chain pull exceeds 2,000 lb., the drive usually is less expensive than a sprocket drive because of the lower torque requirements.

5. A caterpillar drive can be reused on any conveyor, regardless of the radius or angle of horizontal turns. With a sprocket drive, the maximum radius of the turns is limited by the maximum diameter of sprocket obtainable and by the torque rating of the sprocket drive.

Constant and Variable Speeds

Both sprocket and caterpillar drives use the same three basic types of drive mechanisms: (1) Constant speed, (2) vari-pulley, and (3) "full" variable.

CONSTANT SPEED. Constant speed drives often use a V-belt or silent chain from the motor to drive a vertical worm gear reducer. The output shaft of the reducer sometimes has the conveyor sprocket mounted directly on it. More often the output shaft is connected by a spur gear reduction to a drive shaft, usually with anti-friction bearings, on which the conveyor sprocket is mounted. This sprocket can be either the direct sprocket drive, or the drive sprocket of a caterpillar chain drive.

VARI-PULLEY. A vari-pulley drive unit has the same basic arrangement as the constant speed unit except that some type of variable pulley unit is substituted for V-belt or chain drive that connects the motor to the reducer. The ratio between maximum and minimum speeds for motors up to 5 hp., 1,740 r.p.m. is about 3 to 1. For drives requiring more than 5 hp. it is better to use the full variable drive unit.

FULL VARIABLE. For drives requiring a speed range of 10 to 1 or more, a variable speed transmission unit should be used between the motor and reducer. The motor usually is connected to the unit by a V-belt or silent chain and from the transmission to the reducer by a silent or roller chain. The silent chain will be quieter at high speeds, which may be as much as 1,300 r.p.m.

GEARS. Final gear reduction usually are used between the speed reducer and the conveyor drive shaft, although one design uses a roller chain.

Gear reduction units should use cut steel spur gears, with the pinion heat treated for long wear. Since they run at extremely slow speeds, the gearing usually is open. There is a tendency to inclose these gears and run them in oil. One design uses standard drives with inclosed gears, and another eliminates the gear unit by using high ratio combination worm gear reducers with the drive sprocket mounted on the extended reducer shaft.

Fabricated steel frames are used to mount the drive machinery, and to support the conveyor track.

SPEEDS. Speeds can be obtained from a fraction of an inch per minute up to 50 r.p.m., or even faster. Drives for extremely low or extremely high speeds, and for exceptionally high chain pulls should be specially designed. Standard designs usually can meet other requirements.

Drive ratings should be selected on the basis of carrying 100 percent momentary overloads without damage to the drives.

Overload Devices

All drives require some form of mechanical protection for the drive and the conveyor in event of an overload or a jam in the line. The electrical overload device in the motor circuit will not protect the drive because most drives use oversize motors. Overload devices that satisfactorily protect conveyor drives include: (1) The shear flange, or shear sprocket, that connects the final drive shaft and sprocket; (2) the "floating drive" cut-out; (3) the "torque control" unit; and (4) the overload limit switch.

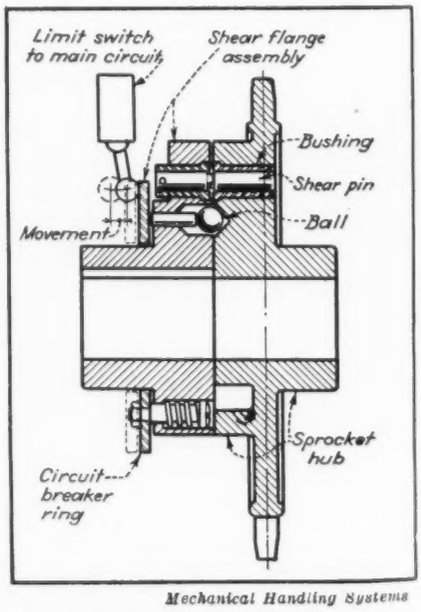
SHEAR SPROCKET. Consisting of two halves, the sprocket-half is not keyseated and is free to turn on the driving shaft while the driving flange-half is keyed and set screwed to the shaft. The driving force is transmitted to the sprocket from the driving flange by a single shear pin carried in a pair of hardened steel bushings.

Shear pins are made of cold rolled steel with a shearing strength of 50,000 p.s.i., and are necked down in the shearing plane to the correct diameter. Table I shows the shearing strength for different neck diameters.

The shear sprocket is the oldest and most commonly used overload device, but is has many disadvantages. It takes time and it is inconvenient to replace a broken pin, which sometimes is jammed or rusted in. When overloads occur frequently, the tendency is to use pins not properly necked down, or alloy steel pins or bolts, thus making the device useless.

The sprocket half may rust fast to the shaft. This often occurs with steel sprockets unless a bronze bushing is used in the bore. After a shear pin breaks, since the motor continues to run until stopped manually, even freely turning sprockets may gall the shaft since the turning parts are not lubricated.

A type of shear hub that stops the motor, but still requires replacement of the shear pin, is shown in Fig. 9. When a shear pin breaks, the balls push the circuit breaker ring to the dotted position, which actuates the limit switch and this stops the motor.



Mechanical Handling Systems

Fig. 9—Failure of shear pin operates limit switch, thereby stopping drive.

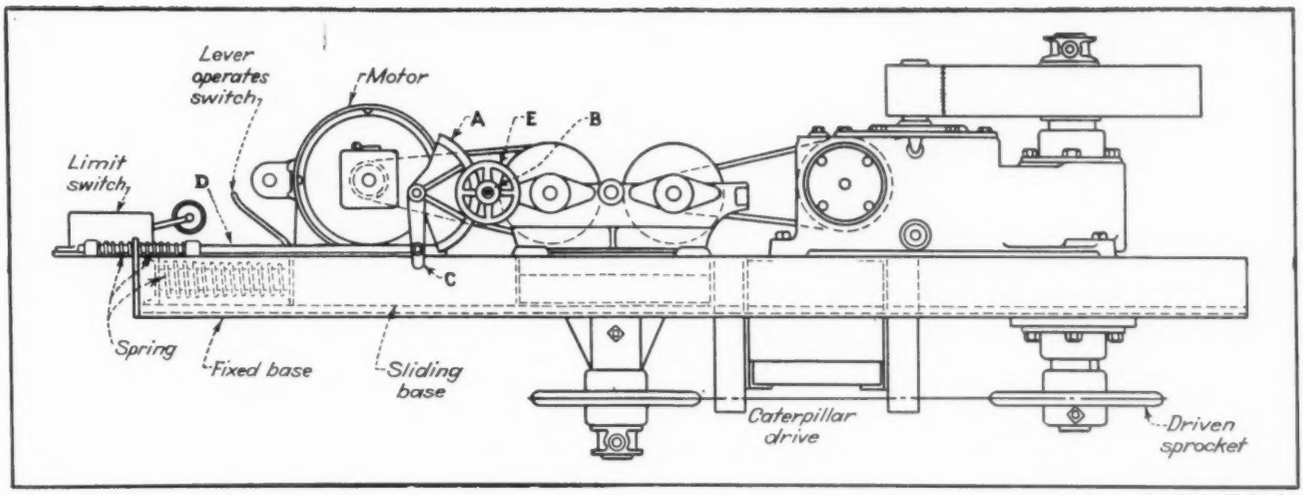


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Fig. 10—Schematic of floating drive showing relation of fixed and sliding bases and operating elements.

FLOATING DRIVE. The floating caterpillar drive is built in a frame that is free to slide on four bronze shoes in a fixed secondary frame that is attached to the conveyor track. The driving effort is resisted by coil compression springs that in event of overload let the sliding frame operate a limit switch to stop the motor. After the cause of overload is corrected the unit immediately is ready to go back into service. The chain pull required to stop the motor is adjustable. No shear pin is required. Floating type sprocket drives are arranged so the spring will resist rotation.

When variable speed units are used with balancing speed control, this drive can be used to couple two or more drive units to one strand of conveyor chain.

As shown in Fig. 10 the control consists of a gear pinion *B* keyed to the adjusting shaft *E* of the variable speed transmission and rotated by a gear segment *A* pivoted on a bracket mounted on the transmission frame with an operating lever *C* of adjustable length. This operating lever is connected, by means of a rod *D*, to the fixed frame of the drive unit. When the drive takes more than a preset load, the sliding frame moves back against the springs producing a rotation in the gear pinion that automatically reduces the speed. Conversely, when the unit takes less than its load, the frame moves forward and increases the speed of the drive. Thus on a conveyor with multiple drives, all of them will automatically maintain their proper proportion of the total driving effort regardless of variable factors such as load conditions or length of chain within the limits of movement of lever arm *C*. Limit switches can be inter-connected so any overload will stop all drives but signals show which drive initiated the stoppage.

Mechanical or electrical controls can be substituted for the hand wheels at *E*, so that speeds on all drives on a conveyor can be regulated together from a central point.

TORQUE CONTROL. The overload and speed control device shown in Fig. 11 can be used on both sprocket and caterpillar drives. A weighted arm causes a slight bend in the final drive chain. Variations in chain pull moves an arm that operates the speed control. When a overload occurs, a limit switch stops the motor. The drive is ready for use again as soon as the overload is removed.

This device can be used to regulate and equalize the speeds of each drive of a multiple drive conveyor. It also can be used on constant speed drives as an overload device only, by adjusting the position of the counterweight.

OVERLOAD CUT-OUT. The overload cut-out is a torque control that works on the high speed side of a drive.

On overload, the cut-out operates a limit switch that stops the motor. When the motor stops, the cut-out resets itself and is ready to run when the motor is started.

The cut-out is designed for a pre-

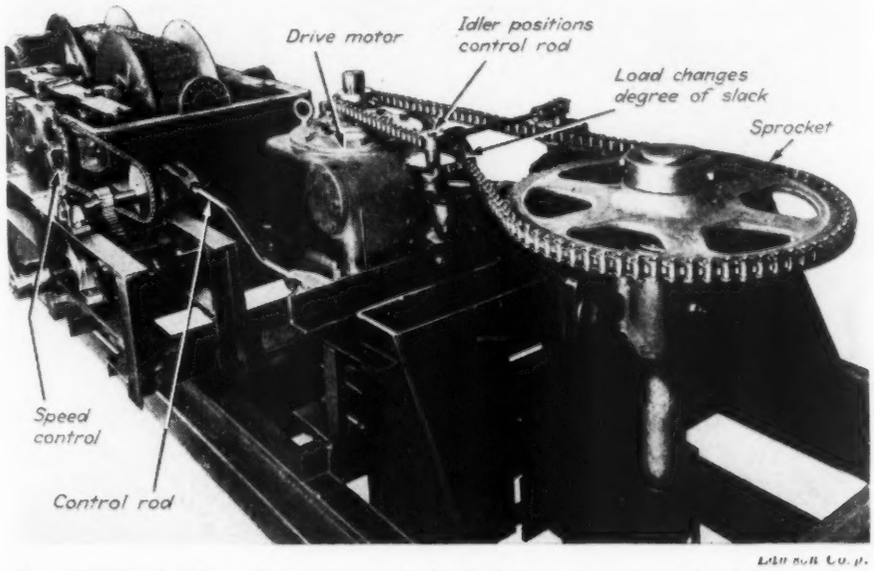

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Fig. 11—The load on this conveyor is limited by torque control. Pull on chain actuates control; system can be used on either sprocket or caterpillar drive.

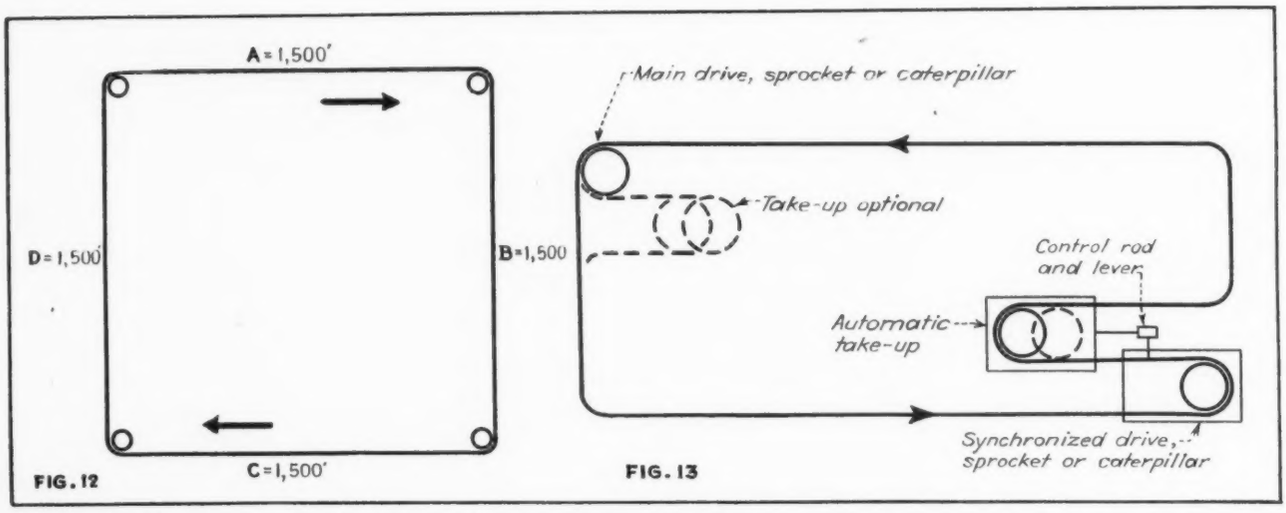


Fig. 12—Matching the speed of multiple drive units is complicated because equal lengths of chain have an unequal number of pitches. Fig. 13—A take-up system operated by accumulated chain slack can be used to equalize the load.

determined torque, but can be adjusted for other torque requirements. It should be used on the high speed shaft of a speed reducer where the torque is constant, and not on the constant speed side of a variable speed drive where the torque varies with load conditions.

With the floating drive, torque-control or overload cut-out, if the drive is started before the overload is removed, the motor will continue to stop until the overload is removed. The limit switch also can be used to ring an alarm, turn on a light, or stop other motors.

Multiple Drives

When the chain pull of a conveyor is too great for a single drive, two or more drives can be used. For example, one conveyor, 11,000 ft. long, uses 14 drives at a constant speed. Another, 8,500 ft. long, uses 5 drives with variable speed. When a conveyor is lengthened additional drives can be added.

The problem of matching drive speeds is complicated, even for constant speed. No two strands of chain of equal length will have exactly the same number of pitches. A 1,000 ft. strand of 458 chain may have 2,970 pitches and the next 1,000 ft. will have only 2,950 pitches. The same length must pass each drive at the same time. The drive sprockets (whether for sprocket or caterpillar drives) have equal numbers of teeth and advance equal numbers of chain pitches per revolution. Also, motors do not run at exactly the same speeds, even when load conditions are identical, and loading is always a variable factor. For example, as shown in Fig. 12, the conveyor has four drives, each powering 1,500 ft. of conveyor. At a given instant:

Chain length A = 1,500 ft. = 4,450 pitches
Chain length B = 1,500 ft. = 4,400 pitches
Chain length C = 1,500 ft. = 4,460 pitches
Chain length D = 1,500 ft. = 4,420 pitches

The drive sprockets of all drives advance the chain 10 pitches per revolution. Table II shows the revolutions each sprocket must turn for each length of chain to pass a drive.

Thus, each drive turns a different number of revolutions for each length of chain, and during any time interval the drives are revolving at different varying rates. By continuous "hunting" the drives keep in proper relationship and do not tighten or loosen the sections of chain they pull. In practice, the drives should be spaced for equal chain pull as nearly as possible instead of equal conveyor length.

Table I—Strength of Typical C.R.S. Shear Pins

(Based on shear strength of 50,000 lb. per sq. in.)

Neck Dia., in.	Shearing Strength, lb.
3/16	1,380
1/4	2,455
5/16	3,835
3/8	5,525
7/16	7,515
1/2	9,820
9/16	12,425
5/8	15,340
11/16	18,560
3/4	22,090
13/16	25,925
7/8	30,065
15/16	34,515
1.0	39,270

CONSTANT SPEED MULTIPLE DRIVES. For constant speed drives, high slip squirrel-cage motors are used. These slow down under heavy loads or tight chains, and speed up under light loads or loose chains. For a large number of drives it is advisable to use low chain pulls and light motor loads to allow the maximum amount of slip in the motors.

Another method is to use standard squirrel cage motors with hydraulic couplings. These are more expensive than high slip motors and require more space.

VARIABLE SPEED MULTIPLE DRIVES. The floating drive and the torque-control drive can be used for multiple drive installations for adjustable speed. Where the speed is controlled manually, a change at one drive will automatically change the speed at the other drives within the range of the arm control. Beyond that limit, the drives must be adjusted individually. With mechanical or electric operation of the speed adjustment, the speed can be varied over the entire range from a single point.

Other types used for variable speed multiple drives include the differential power drive, differential

control drive, and the take-up control system. The differential power drive is seldom used, as other types are less expensive and easier to build.

The differential power drives must be located close enough to each other to be driven by a single motor drive unit, and to divide the load equally. The differential works like that in an auto axle transmission and is a heavy duty, high torque type.

The differential control drive also is seldom used. It requires the drives to be located close together and can be used for only two drives.

Take up control is used with dual drives. When the main drive speeds up or slows down under load, or if its speed is changed, the slack accumulated in the conveyor chain causes the take-up to move, which changes the speed.

The take-up must be installed at the synchronized drive, though it may not be required otherwise. A take-up at the main drive is optional.

Table II—Relative Sprocket Revolutions for 4-Drive Conveyor

Conveyor Drive	1st Phase		2nd Phase		3rd Phase		4th Phase	
	Chain	Rev.	Chain	Rev.	Chain	Rev.	Chain	Rev.
1	A	445	D	442	C	446	B	440
2	B	440	A	445	D	442	C	446
3	C	446	B	440	A	445	A	442
4	D	442	C	446	B	440	A	445

Motor Drives

Alternating current, polyphase motors cannot be used where the speed of the motors must be varied gradually over a considerable range, and when once adjusted, will remain practically unaffected by variations in loads. Adjustable speed motors and control, with inherently stable speed characteristics are used for multiple drives. Since the power supply in most plants is alternating current, it must be converted to direct current by a rectifier or motor generator unit.

Adjustable d.c. control systems convert alternating current to direct current for powering special conveyor motors with proper characteristics to maintain speed and load sharing synchronization.

The entire conversion unit, which may be electronic or rotating, with all necessary controls, can be mounted in a single cabinet. Start and stop operations are interlocked so that all motors function as one, and speed setting of the entire conveyor is obtained from a separately mounted rheostat conveniently located.

Often a central control panel shows individual motor loads for closer synchronization of the entire conveyor drive. An ammeter for each motor shows the motor's performance, and a vernier rheostat provides precise adjustment. Calibrating resistors carrying armature current establish equal terminal voltage at each motor when the drive is started up and are usually mounted in the rear of the panel. Other devices on the panel include a voltmeter for exciter and generator voltages, a push button station and main speed setting rheostat. Features of a d.c. drive include: (1) A wide speed range of infinite steps; (2) perfect paralleling of the conveyor motors over the entire speed and load ranges; (3) elimination of mechanical speed changers and simplification of the drive machinery; (4) a smooth, cushioned, and gradual start, and dynamic braking for stopping; (5) synchronized central control from one station, with separate control and visual indication of each motor's performance, and change of speeds over the entire range while the conveyor is in motion.

Direct curent multiple drives require power wiring from the conversion unit to each motor. This cost, added to that of the conversion unit and the relatively expensive d.c. motors, make this drive cost more than the mechanical speed control.

Iron Used in Electron Tube Components

PURE DEGASSED IRON can effectively replace molybdenum and nickel in the construction of electrodes, getters, and other metallic parts of electron tubes, according to a Japanese research document included in a report now on sale by the Office of Technical Services, Department of Commerce. The report, prepared by Major Wilhelm Jorgensen for the U. S. Naval Technical Mission to Japan, consists of five studies by leading Japanese experts in electronics.

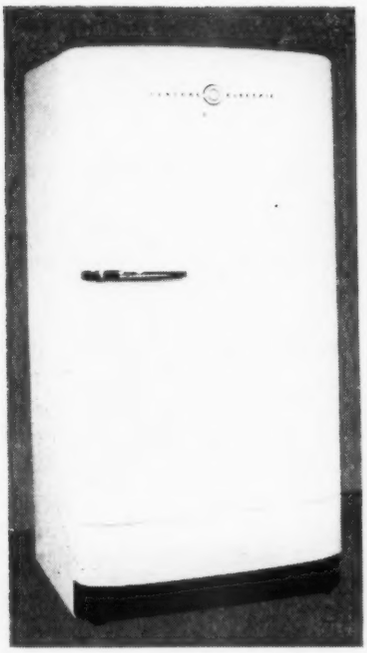
Shortages of nickel and molybdenum during the war compelled Japanese engineers to investigate the use of iron for vacuum tube parts. They discovered that iron, when freed of occluded gases, possessed the durability and the electron emission characteristics comparable to those of molybdenum and nickel. However, the production process was more tedious and costly.

The raw material for the iron used in electron tubes was iron sand. The sand was reduced in an electric arc furnace and the iron metal drawn off. The metal was then melted in a high frequency electric induction furnace and deoxidized with silicon and aluminum. As a result of this treatment the iron contained less than 0.02 percent of oxygen—the most harmful of the occluded gases—and therefore became a suitable construction material for small electron receiving tubes. However, large power tubes required iron with an even lower oxygen content. To obtain such purity, the iron after deoxidation with silicon and aluminum was heated in a stream of hydrogen at 1,100 degrees centigrade for two hours. The final oxygen content was less than 0.004 percent.

Orders for the report (PB-49839; "Japanese Electronic Tubes"; photostat, $3; microfilm, $1) should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C., and should be accompanied by check payable to the Treasurer of the United States.

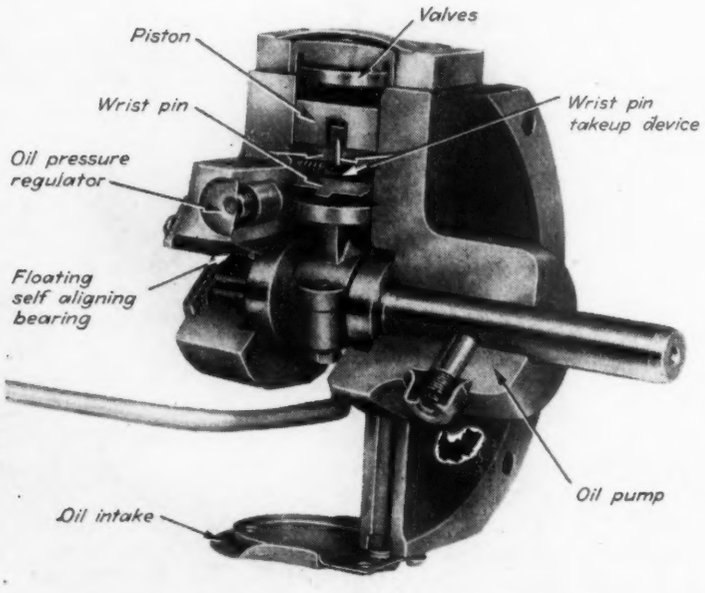
Smaller Compressor Increases Refrigerator Capacity

A stator frame that houses the compressor and a more compact motor winding are combined to increase usable space in the redesigned 1947 General Electric refrigerator.

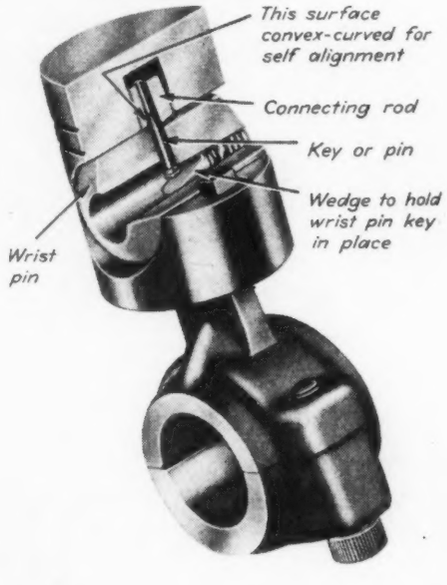


1 REDESIGN objectives were to reduce the number of models and to obtain more storage volume in a given cabinet space. Icemaking capacity is increased 30 percent, while operating cost is reduced 15 percent.

2 FREON 12 replaces sulphur dioxide as the refrigerant. This is done for safety and to enable use of plastic insulated wire. The Formex insulation occupies less space and is more durable than cotton insulation. Under accelerated life test the motor durability has been increased from 30 days to 480 days without failure.

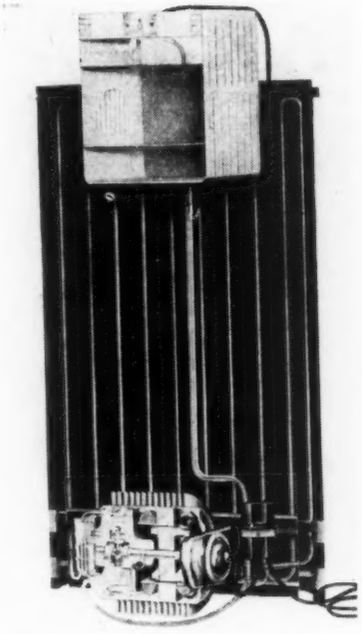


6 COMPRESSOR has been designed for a 25-year service life. Reduction of wear is the principal objective. The scotch yoke piston drive has been replaced by a connecting rod-wrist pin linkage, with a piston pin takeup device that prevents push-pull play of the pin. Bearing opposite motor end is self aligning so that there is no binding under load. The "duck-billed" oil intake picks up a smooth layer of oil, without cavitation.

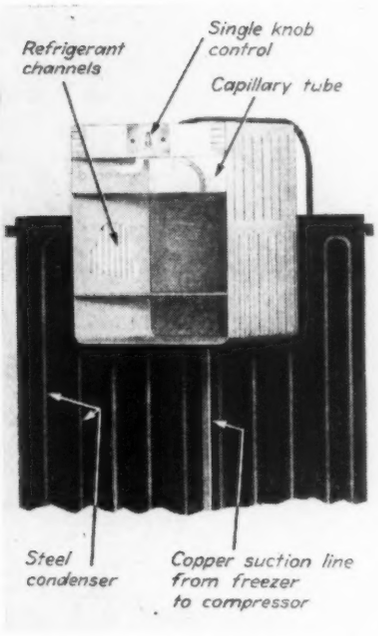


7 SPRING-LOADED WEDGE and locking pin prevent backlash between rod and wrist pin, and prevent wrist pin rotation in the rod. Rotation between rod and piston must then take place in the oversize bushed end bearings. Connecting rod bearing surfaces are convex to allow freedom of alignment.

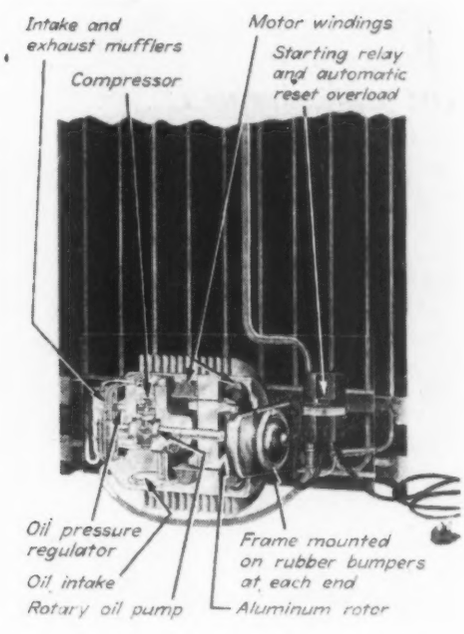
DESIGNS



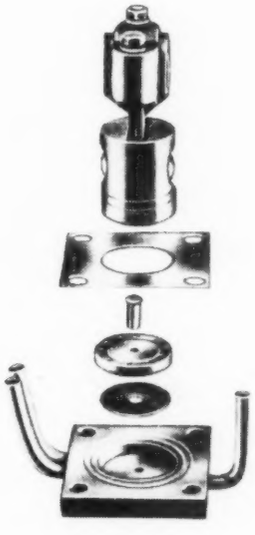
3 **COMPRESSED VAPOR** is cooled by natural draft over the welded steel condenser. The liquid refrigerant evaporates in channels in the walls and shelves of the stainless steel freezing compartment.



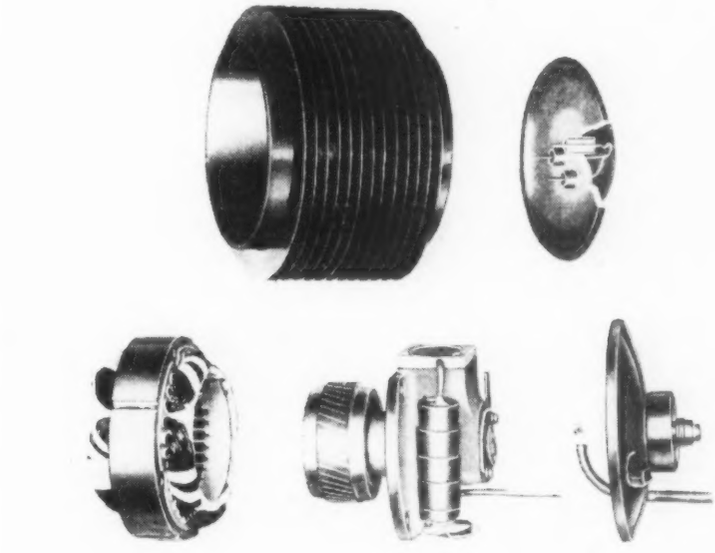
4 **FUSED-IN-GLASS** wire leads to the motor are leak proof. Starting relay automatically connects the starting winding in parallel with the running winding of the motor, cutting out the former when motor comes up to running speed.



5 **BELL SHAPES** on ends of compressor-motor housing ride in rubber bumpers that protect the unit in shipment and reduce vibration transmission in use. The relay has an automatic reset overload device to protect the motor from over or under voltage, or overload conditions.



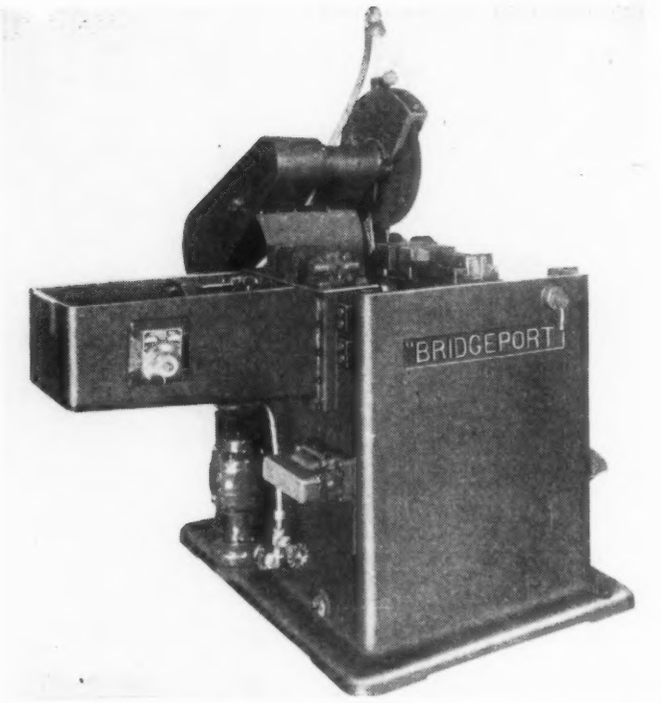
8 **MUFFLE BOX** surface is crowned so that when edges are bolted tightly, the interior seal must be complete. Intake valve formerly had a center flapper. Design was changed to avoid failure through stress concentrations at arm junction with inner circumference.



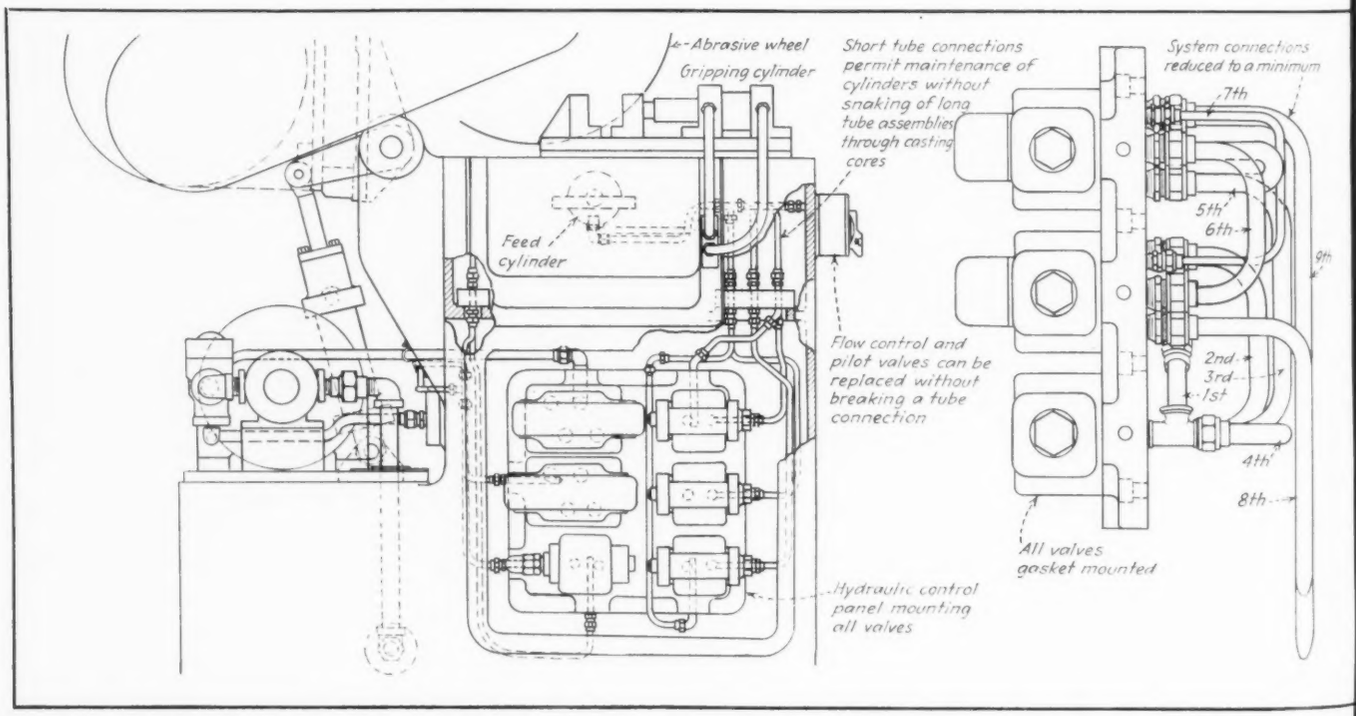
9 **FORMERLY** the motor-compressor assembly was spring-mounted in an outer housing. Now the stator case is extended to include the compressor. Improved magnetic steel saves ½ in. of motor stackings. This total space saving enables the new 8 cu. ft. model to be built with exterior dimensions of former 6 cu. ft. model. Steel cooling fins on the housing have thin plastic rims, not shown, that deaden vibration. End caps are thicker to reduce vibration of the unit when in operation.

Manifolding Provides A Compact Hydraulic Control Panel

Hydraulic circuits can be simplified and combined into a design as unified as that of an electrical control panel. An example is on the Model 51 Automatic Abrasive Cutoff Machine, built by Bridgeport Safety Emery Wheel Co., Bridgeport, Conn. Instead of random placement of valves with correspondingly long connecting lines, all valves are mounted on a single control panel fixed on the side of the oil reservoir. In this hydraulic system redesign by E. Lomazzo & Associates, many feet of piping are saved, and maintenance is simplified. The panel is on a versatile, high production, abrasive cutoff machine.

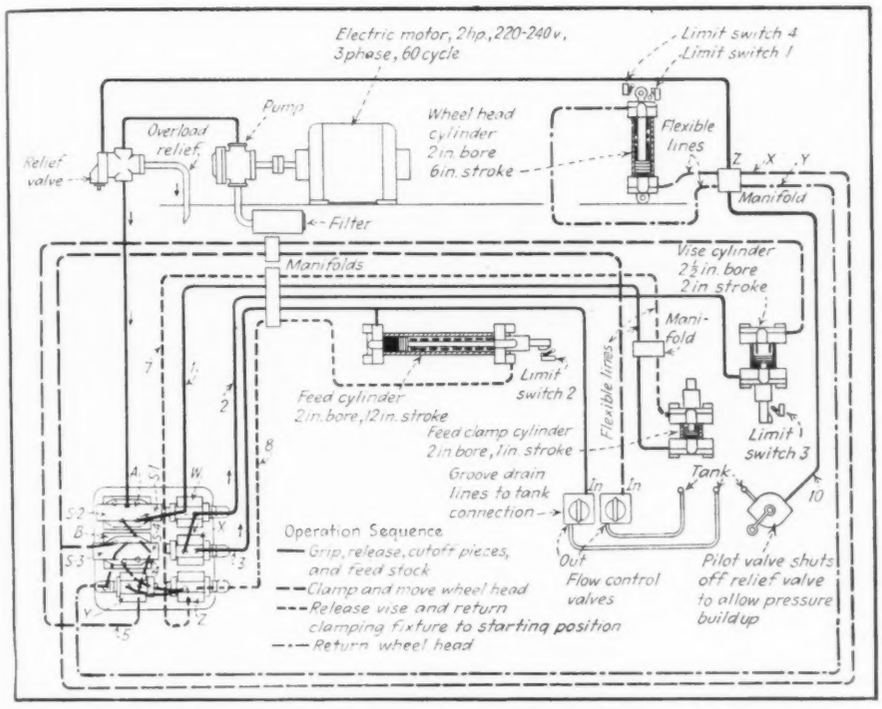


1 **THIS AUTOMATIC,** all-hydraulic, chopper-type head machine will cut up to 3 in. thick material. Thin material can be nested for high production cuts. Length between cuts can be selected up to 12 inches. Longer cuts can be provided for by a special cylinder with longer piston travel.



3 **TO OBTAIN** a simple hydraulic circuit design, the sequence valves are assembled on a single control panel with the 4-way valves adjacent on the same panel. Circuit lines come off the rear of the panel, over the oil reservoir so any leakage will drip into the tank. This construction saves piping, makes maintenance easier and reduces oil loss. Assembly is much simplified because control lines do not run off the panel to various parts of the machine, requiring laborious fitting. For further ease of maintenance the cylinder lines are run into manifolds, so that

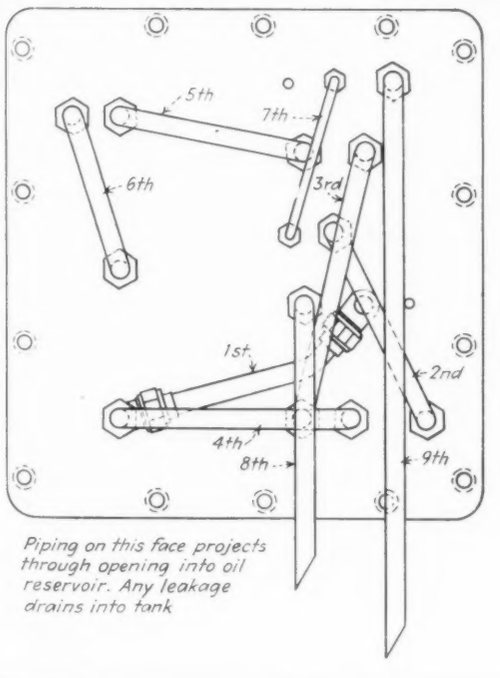
D E S I G N S



2 HYDRAULIC FEEDS and electrical controls provide for a completely automatic cycle of feeding, clamping and cutoff. The system includes a motor driven hydraulic pump, four hydraulic cylinders, a four way valve and suitable control valves and switches. Operation of pilot valve blocks vent line from main relief valve, allowing pressure to build up in the system.

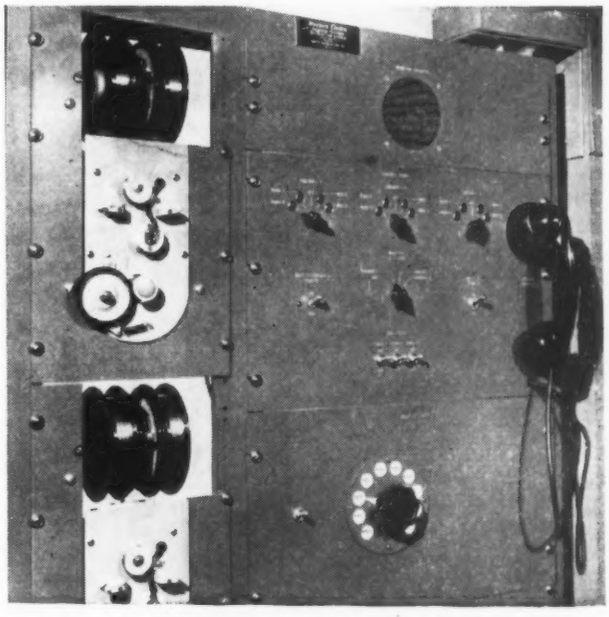
System Operation

Pressure through 4-way valve **A** and line 1 to feed clamp cylinder operates the clamp fixture to grip the stock. Pressure in line 1 operates sequence valve **W** so line 2 can operate vise cylinder. This releases end of stock and piece cut off in preceding cycle. Vise opening energizes solenoid **S**-3. Pressure through line 3 feeds stock to cut-off position in the vise. At end of feed stroke, solenoid **S**-2 is energized, reversing 4-way valve **A**. Two circuits then operate. In the primary, pressure through lines 4 and 5 clamp the work for cut-off. Pressure through sequence valve **Y** and 4-way valve **B** feed the wheel through the work until the wheel contacts switch **LS**-4. The secondary, also through **Y**, operates the feed clamp cylinder by line 7 to release stock in vise. Pressure in line 7 operates valve **Z** so pressure through line 8 turns the clamping fixture. As the wheel contacts **LS**-4, solenoid **S**-4 is energized, reversing 4-way valve **B** to return the wheel head. On its return stroke the wheel head carrier operates switch **LS**-1, resetting **A** for next cycle.



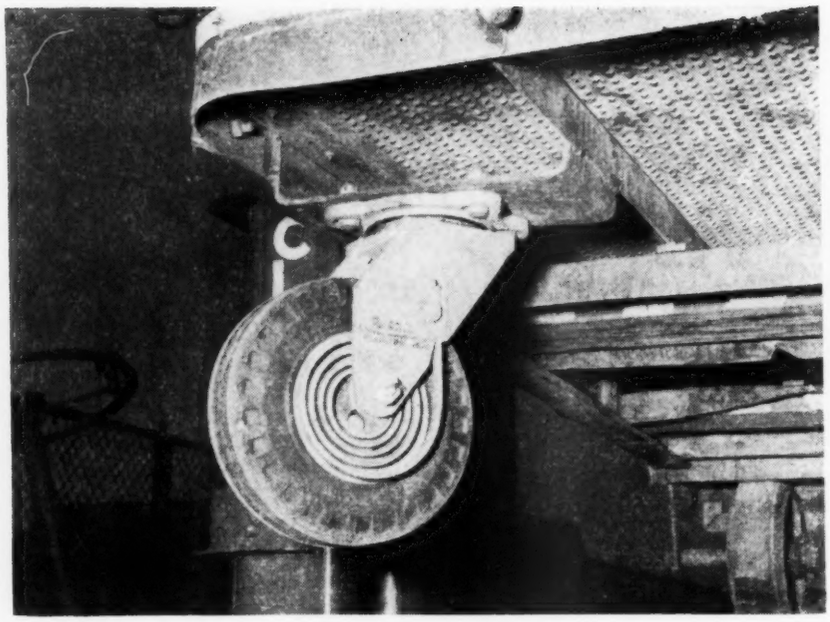
Piping on this face projects through opening into oil reservoir. Any leakage drains into tank

only short lines in simple shapes need be broken when servicing. For strength, the lines are run in a group and fastened together for mutal support. Bleed-off valves control the rate of travel of the wheel head and feed stroke. Valves can be serviced by removing mounting screws.



Railroad Sound System

THIS PROGRAM DISTRIBUTION SYSTEM has been designed by Western Electric Co., Kearny, N. J. Two radio input channels, each with pretuned station selectors, are supplemented by two wire recorders, each furnishing three hours' entertainment. Handset is for announcing stations and points of interest. Three output channels supply different programs to sections of the train.

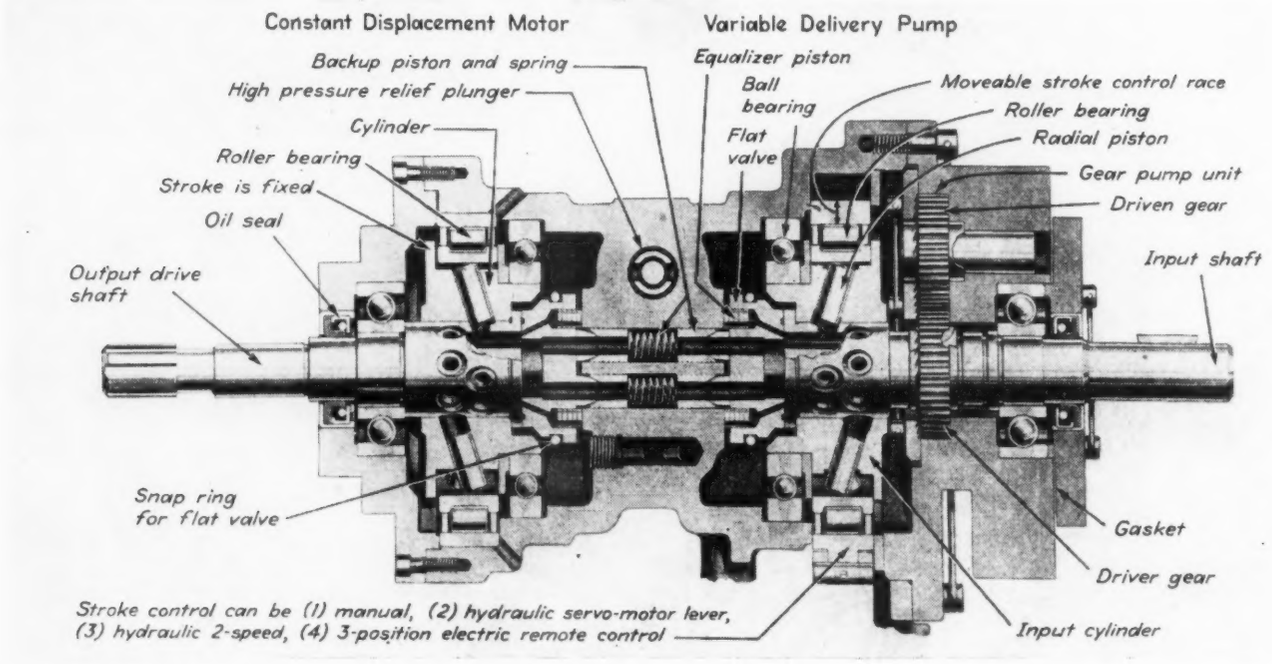


Floating Hub Absorbs Shocks

A COILED STEEL SPRING provides resiliency between wheel rim and axle of this simple shock absorbing caster. The spring will support the load when hub is off center, thus allowing the wheel to remain in uneven ground. Knee action effect of these casters on airport cargo trailers has enabled speed increase from 15 to 25 mph and reduced caster breakage 75 percent. The floating hubs are made by the Bassick Co., Bridgeport, Conn.

Radial Piston Pump for Variable Speed Transmission

This system uses a variable delivery, radially-rolling piston pump, driving a constant displacement, radially-rolling piston motor with hydraulic servo-motor control. The power fluid provides lubrication. Constant mechanical rotation is converted into controlled, variable rotary motion, with uniform acceleration from zero to maximum in either direction.



2 HYDRAULIC TRANSMISSION comprises gear pump, variable delivery radial piston input unit, constant displacement radial piston output unit, and a hydraulic control. Input unit has a drive shaft pressed into a cylinder having 14 radial pistons, a movable stroke control race, and a roller bearing. Output unit is identical except instead of the control race, a roller bearing is fixed in maximum stroke position. Servo control unit is a manually operated spiral valve, which positions two opposed pistons that position the stroke control race. Two piston bores in input shaft are connected with each of seven axial holes. The fourteen piston bores in cylinder coincide with fourteen piston bores in drive shaft. The race can be operated by methods noted on diagram, including remote control.

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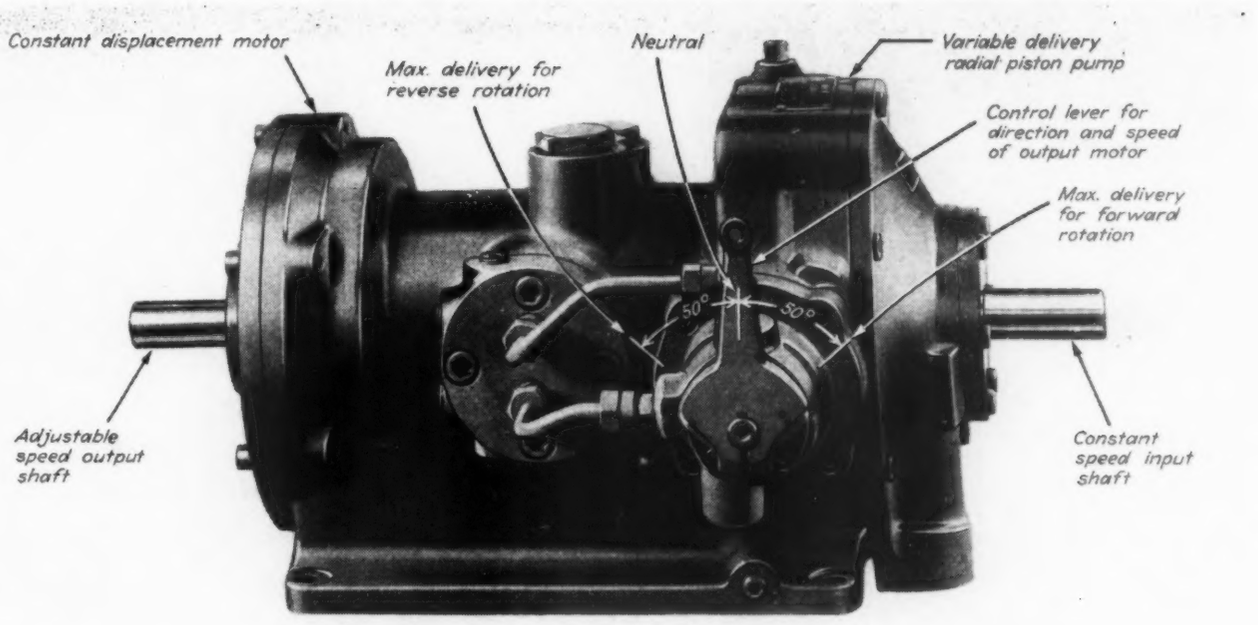
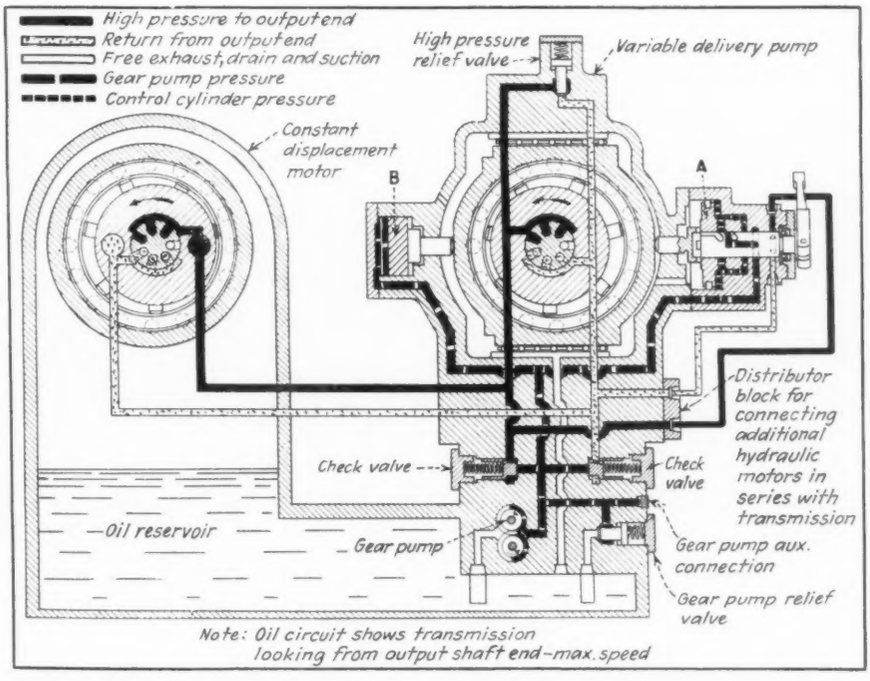


1 **THE SYSTEM TORQUE** in in-lb is: starting, 125; running, 90; peak, 135 for 10 percent of time. Motor input ranges from 2 to 3 hp, 1,750 rpm max; at normal torque, output speed is variable from 0 to 1,600 rpm either forward or reverse. Net transmission weight is 90 pounds. Different control systems for changing speed include: (1) Hand control by 3.4 turns of small graduated knob; (2) hydraulic servo-motor lever control for stepless variation and 2-speed control for remote selection of preset speeds; and (4) electric 3-position control for remote manual or automatic control by pushbuttons or switches. The fluid power transmission is built by the Oilgear Company, Milwaukee.



3 **GEAR PUMP** maintains a 125 psi supercharging pressure on the system. Centrifugal force plus oil under pump pressure beneath each piston, forces pistons always to ride against inner surface of stroke control race. In neutral, stroke control race assembly is concentric with drive shaft. The pistons are at zero stroke and no oil is delivered by the input unit. Operating mechanism is inclosed in compact case; integral relief valves in fluid passages protect against overload conditions. Oil reservoir can be integral with machine or separate.

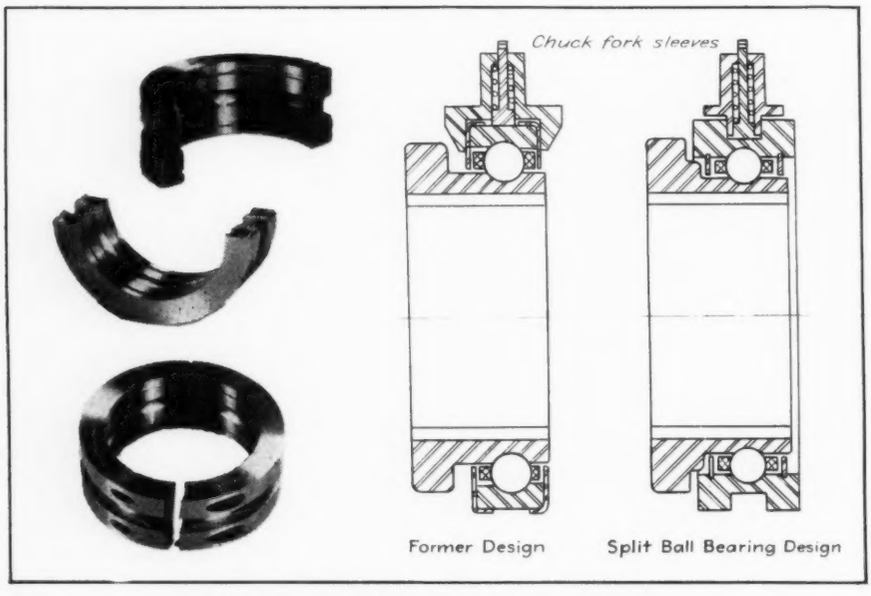
WITH STROKE CONTROL RACE in position shown, the input shaft and control race are not concentric. Thus, as each piston moves counterclockwise through the lower arc, it gradually moves outward. Chamber beneath each piston fills with oil from output unit. Through the upper arc pistons gradually move inward. While passing through upper arc they discharge the oil through axial holes in the input shaft. The oil flows into output shaft axial holes that are passing over the upper crescent, and into the chambers beneath pistons that are in the upper arc. Forces from this oil pressure cause cylinder and output drive shaft to rotate. As these pistons move below the horizontal centerline, they gradually move inward to discharge oil through axial holes in output shaft. Thus the oil passes successively from motor and back forming a closed cycle system of specified displacement. The stroke control race is shifted past center in opposite direction for reverse.

As shown in the sketch of the hydraulic transmission, two flat valves are used to connect main fluid passages between the pump and motor.

Axial Air-Gap Reduces Space And Weight In Motor

A radical departure from conventional motor design adapts this Fairbanks-Morse motor to flange mounting on gear units and direct-drive machines. The motors are about half the size and 70 percent of the weight of comparable standard models.

1 **OTHER ADVANTAGES** are reduced overhang, simplicity of servicing and a cooler-running rotor. Minimum shaft and flange eccentricities and shaft and face runouts are achieved. The WR^2 effect of the axial air gap motor is about three times that of a corresponding conventional motor, a helpful effect in reducing peak electrical loads on punch presses, pumps and similar mechanical units.



Split Ball Bearings Cut Assembly Time

THE SPLIT BALL BEARING on Brown & Sharpe Automatic Screw Machines has the outer race fractured. Surface irregularities serve as keys for maintaining exact race alignment. Purpose is to avoid production delays while assembling bearings into sleeves. Other advantages: bearing shields do not maintain position through spring action and do not transmit pressure of chuck fork; if the bearing has to be replaced, there is no delay while reshipping to the bearing factory. The redesign of this bearing avoided a serious production bottleneck in the factory.

Impact Drive Mechanism Prevents Motor Overload

The 4U Electric Hand Tool has a mechanism that permits the spindle to stall while the motor continues to run. After resistance to spindle rotation reaches a predetermined amount, power from the motor is converted into rotary impacts. Tool is manufactured by Ingersoll Rand Co., New York.

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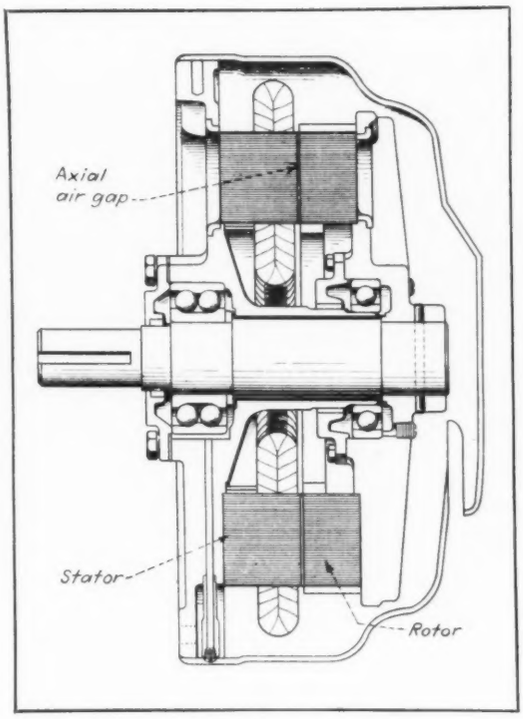
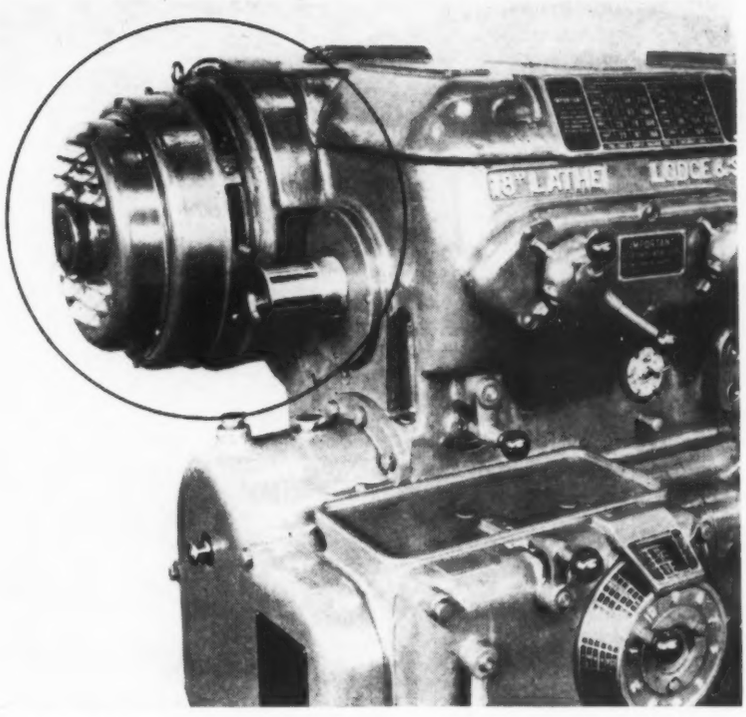
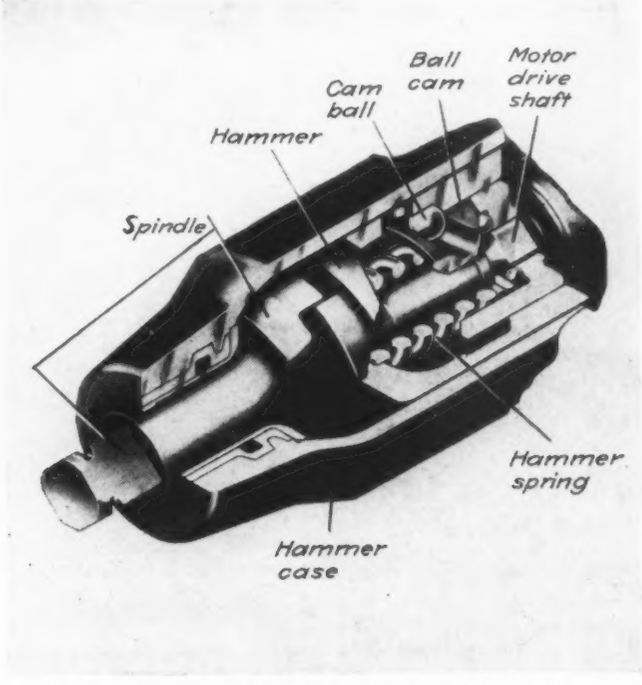


2 MAGNETIC LINES of force follow a path parallel to the axis of rotation instead of the usual radial path. The principle is not new, but the construction embodied here has resulted in a commercially practical motor design.



3 SUPPORTING MEMBER of stator also supports bearings on an integral hollow cylindrical extension through center of coils. Inner race of rotor and bearing is stationary. This construction enables the length of air gap to be controlled through axial measurement of shaft length and rotor and stator facing dimensions.

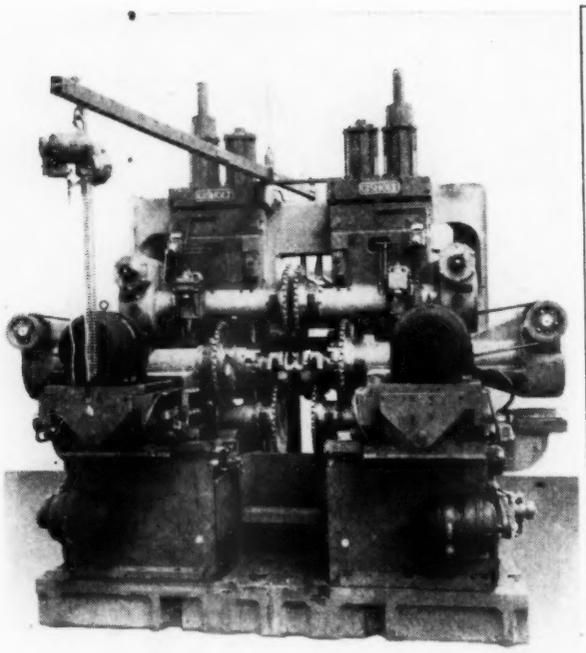
1 OPERATIONS such as drilling, sawing, wood boring, tapping, stud driving and masonry drilling can be performed without torque reaction to the operator. Turning a knob on the end of the aluminum housing reverses 2,000 rpm universal motor. Tool weighs 6½ pounds.

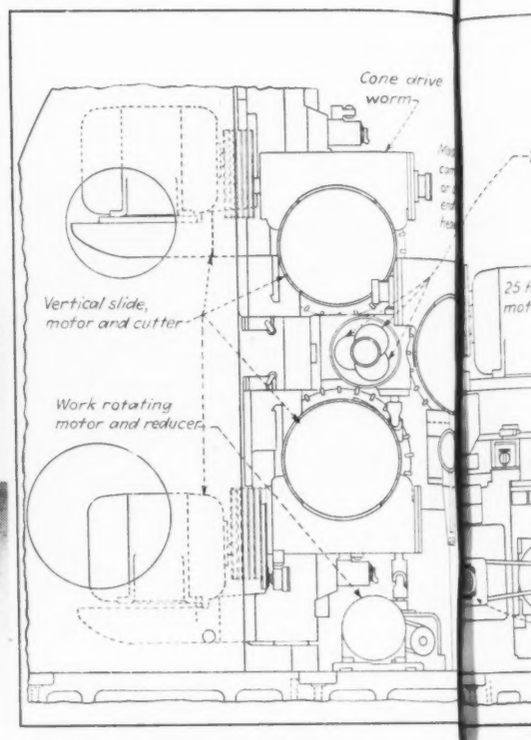


2 WHEN SPINDLE RESISTANCE is greater than spring pressure, spindle is stationary. Rotation of ball cam causes the balls to roll in the cam grooves, pulling the hammer back and compressing the spring. When hammer jaws pass spindle jaws, hammer is pushed forward.

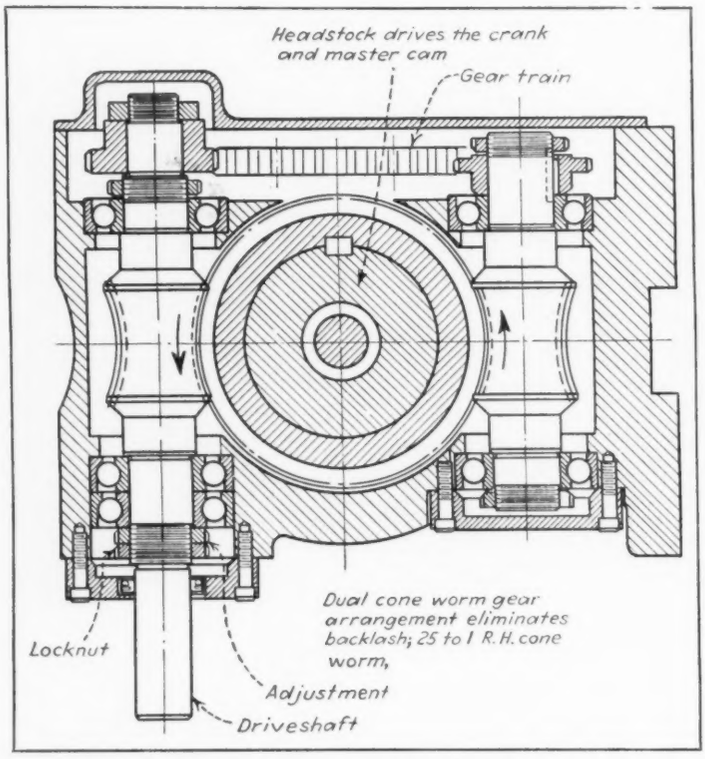
Master Cams Control Cutters

All six pins and cheeks in a crankshaft are machined simultaneously in the Turn Miller, developed by Gisholt Machine Co., Madison, Wis. The machine produces 25 crankshafts in 48 min working time. Weight is more than 100,000 lb.

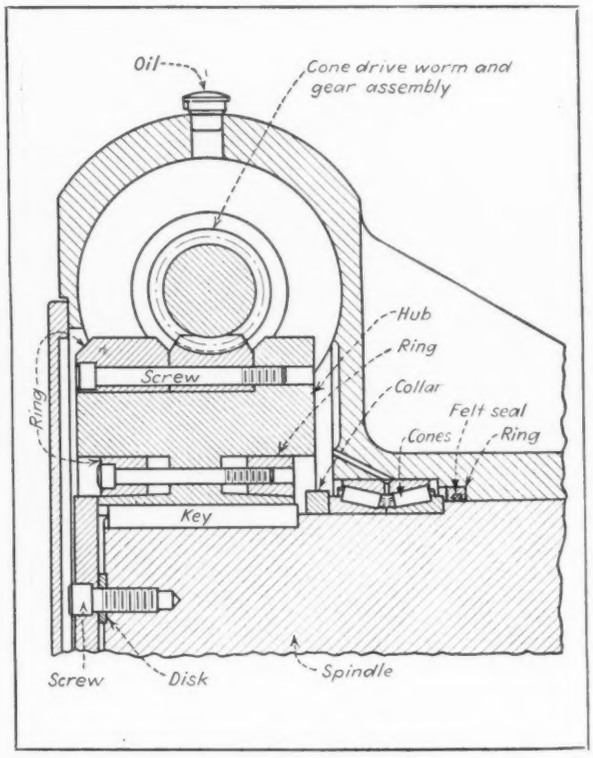




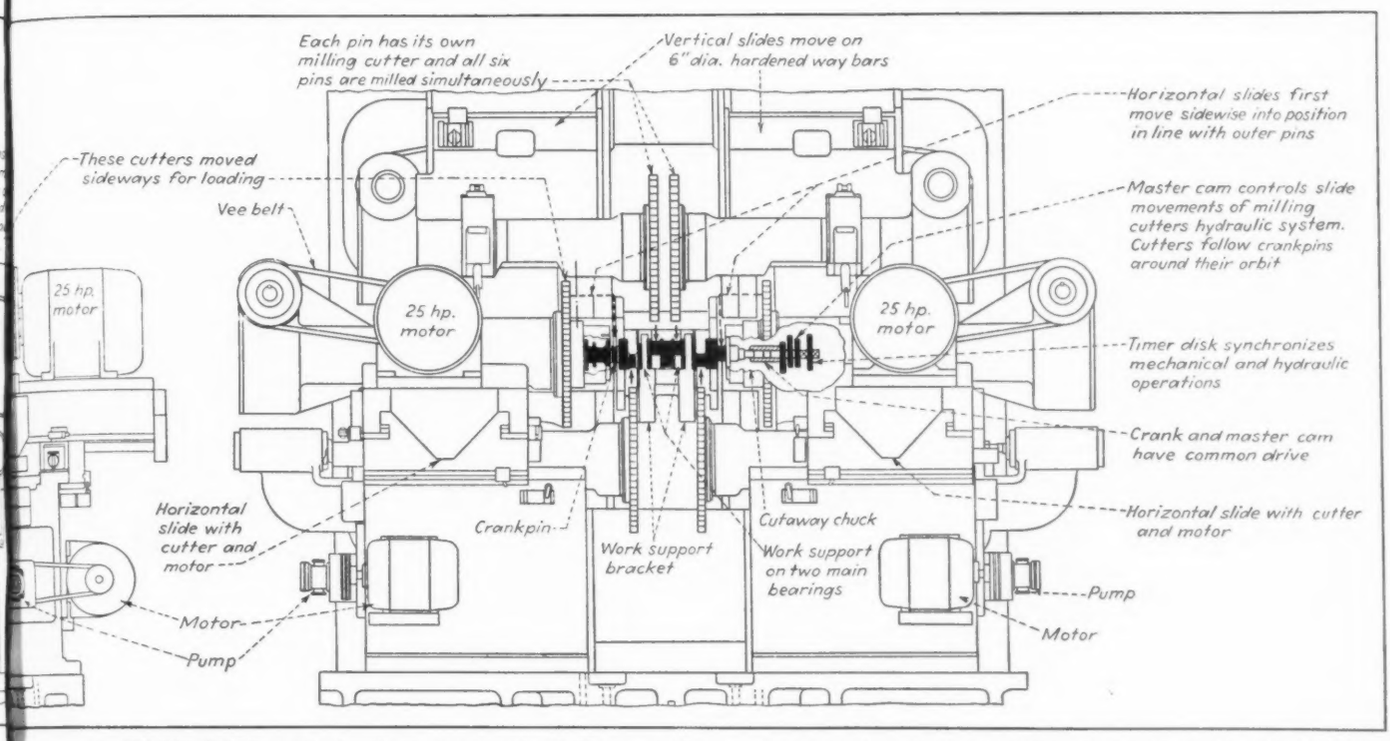
1 EACH PIN has its cutter driven through worm gearing by an individual 25 hp motor. Four cutters move only in a vertical plane; the other two move horizontally, and also move sidewise to facilitate loading and unloading. The movement of the six 24 in. diameter cutters is controlled by a pair of master cams mounted rigidly to the two work spindles. Machine exemplifies careful design integration of different components.


Headstock drives the crank and master cam
Gear train
Dual cone worm gear arrangement eliminates backlash; 25 to 1 R.H. cone worm,
Locknut
Adjustment
Driveshaft

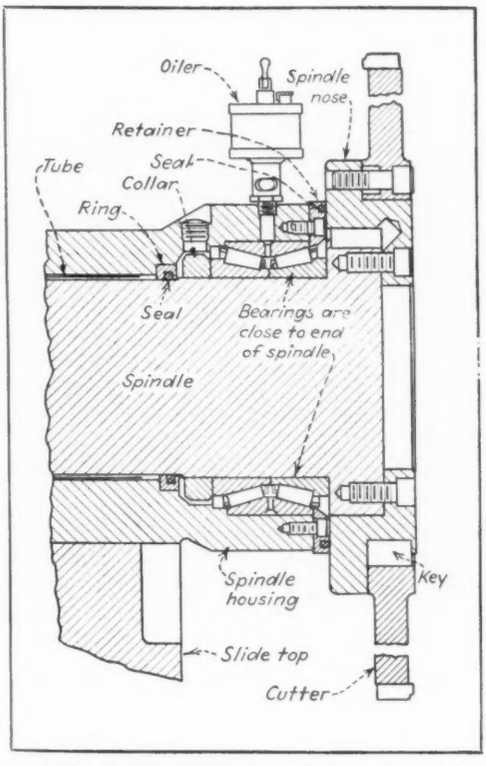
3 BACKLASH is eliminated from the headstock drive by two adjustable worm gears placed diametrically opposite each other. The worm gears are connected directly by a gear train.



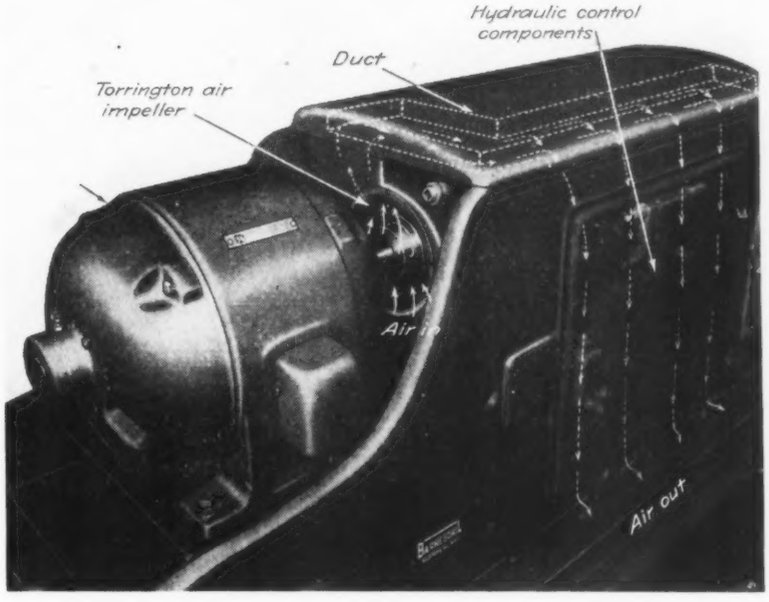
4 MASSIVE HUB and rings form an effective built-in flywheel for the spindle assembly, resulting in smooth operation of the cutter on the workpiece.


Each pin has its own milling cutter and all six pins are milled simultaneously
Vertical slides move on 6" dia. hardened way bars
Horizontal slides first move sidewise into position in line with outer pins
These cutters moved sideways for loading
Vee belt
Master cam controls slide movements of milling cutters hydraulic system. Cutters follow crankpins around their orbit
25 hp. motor
25 hp. motor
25 hp. motor
Timer disk synchronizes mechanical and hydraulic operations
Crank and master cam have common drive
Horizontal slide with cutter and motor
Horizontal slide with cutter and motor
Crankpin
Cutaway chuck
Work support bracket
Work support on two main bearings
Pump
Motor
Motor
Pump

2 EACH CAM controls the movement of three cutters through a hydraulic system acting on the milling cutter slides. The hydraulically operated slides move in unison with the master cams to follow the crankpins around their orbit as the crankshaft is rotated around its main axis. Construction design features include headstock backlash eliminators, rigid work supports on center crankshaft bearings, and milling cutters supported on antifriction bearings with practically no overhang. Machine is of sturdy construction for accuracy and for withstanding high forces.



5 FOR RIGIDITY and accuracy of cutting, bearings are placed at the end of the spindle as close to the cutter as practicable.

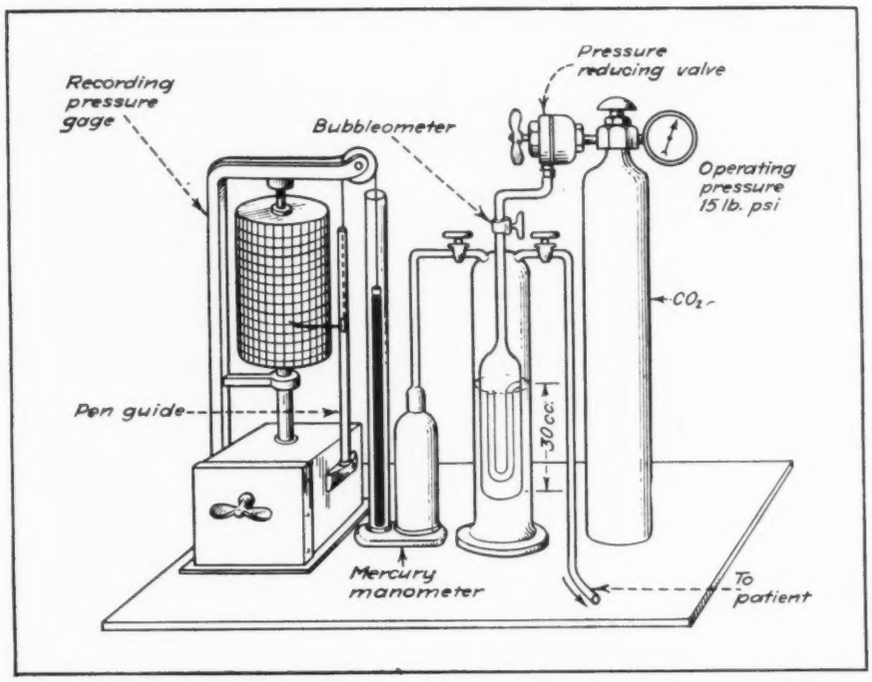


Air Cooled Hydraulic Control Panel

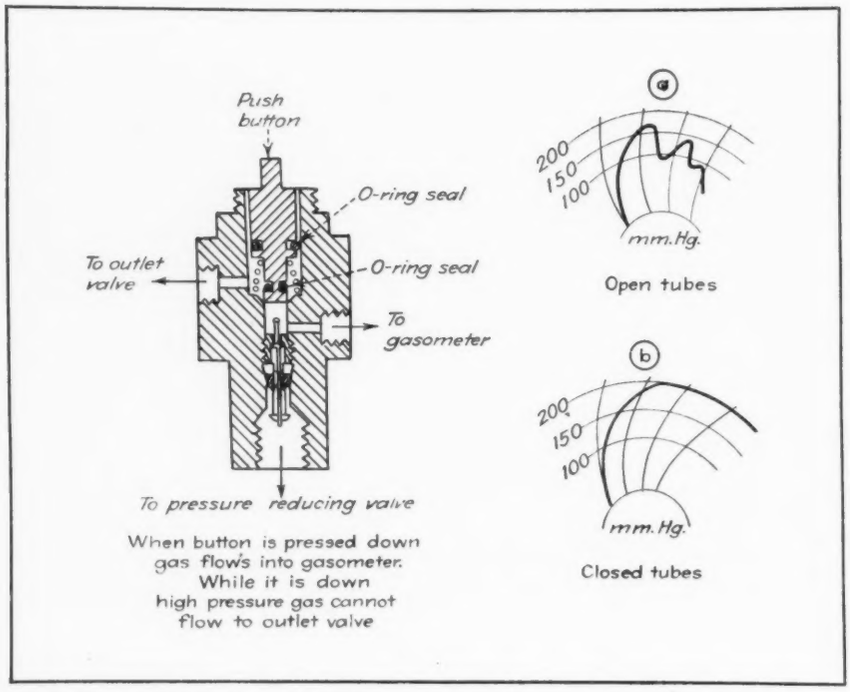
A **BUILT-IN FAN** and duct system directs a flow of cooling air across the elements comprising the hydraulic control panel for this Barnesdril No. 10 hydraulic unit with a 24 in. spindle travel. By dissipating heat at the relief valve and volume control mechanism where most of it is generated the cooling air is most effective. Fan forces air around the different heat-producing elements in the inclosed hydraulic unit, as shown.

Gasometer Increases Medical Instrument Safety

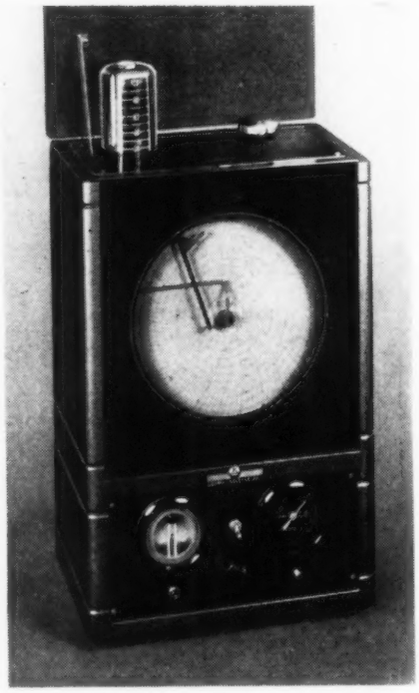
Insufflator was designed by Charles Davies Associates, Product Engineers, N. Y., to avoid possibility of error. With one control it supplies a fixed quantity of gas at a limited pressure. Pressures are recorded on a circular chart.



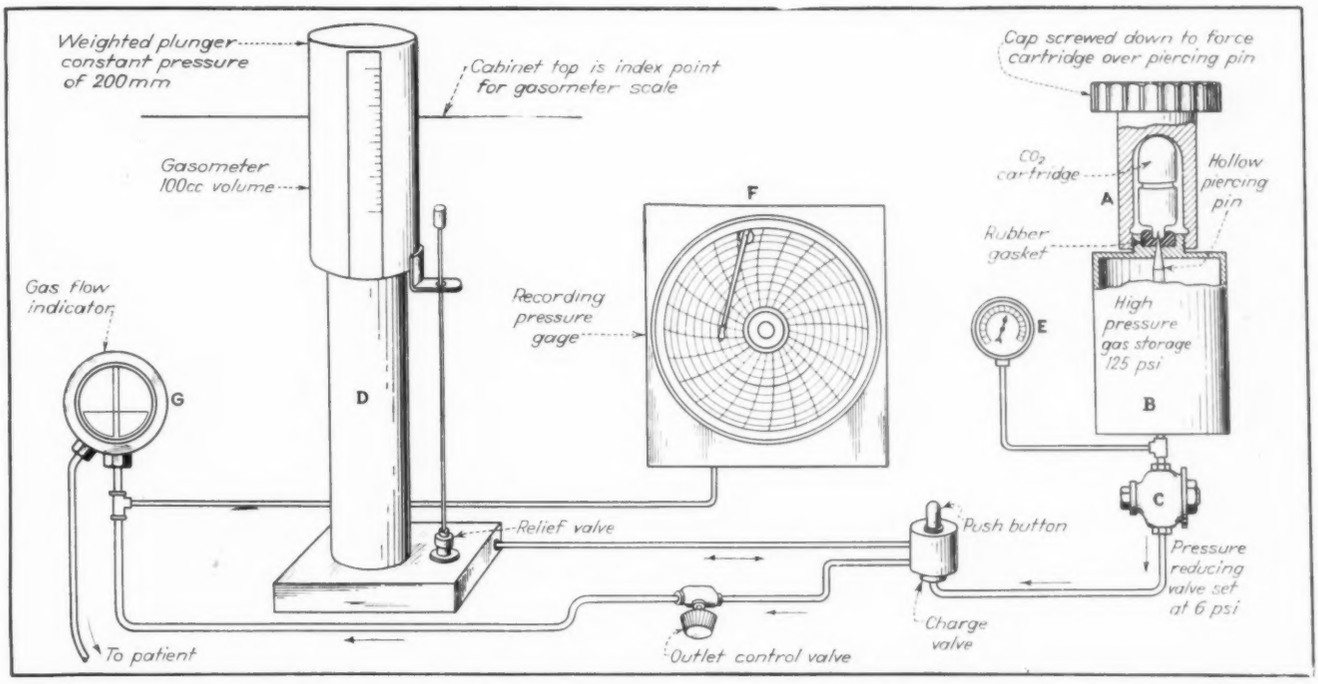
1 ON FORMER INSUFFLATORS the physician had to hold pressure at 200 mm of mercury while not letting over 100 cc of gas enter the patient by manipulating four hand valves. As the bubble-ometer valve was opened, water was forced down until it cleared the bell mouth. Gas would then escape to the delivery tube. By counting bubbles, the physician estimated the volume of gas that passed into the patient. Pressure was controlled by the hand valve.



3 FOR SAFETY, the push-button charge valve is interlocked so that high pressure gas cannot flow to the patient while the gasometer is refilling. Two O-rings seal the outlet valve line from the storage cylinder-gasometer line whenever the button is pressed. A gas flow indicator gives visual indication of operation. A standard recording pressure gage shows variations in uterine pressure. These charts have value as records for clinical study.



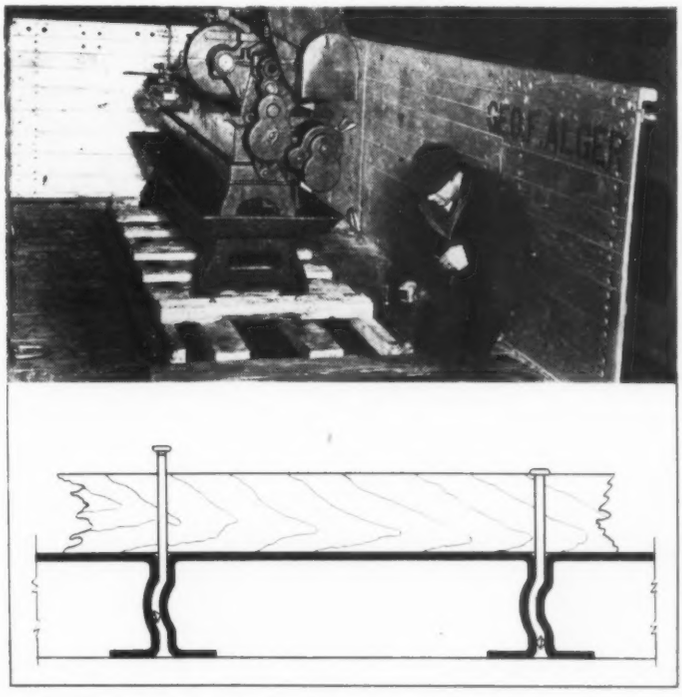
4 NEW INSTRUMENT has many advantages: Safe volume cannot be exceeded. Pressure is automatically limited, but can be increased by pressing on piston. Single knob controls flow. Recharging is done while in use.



2 THE DAVIES INSUFFLATOR is built around a steel cylinder, 100 cc volume holding a piston weighted to limit the pressure to 200 mm of mercury. When the charging valve button is pressed, gas from the storage tank fills the cylinder and forces the piston to rise. Overcharging is prevented by a finger on the piston cover engaging the relief valve rod. As the outlet valve is opened and gas flows to the patient, the piston descends with the lessened volume. If the Fallopian tubes are closed, the pressure will increase, but cannot exceed the pressure imposed by the weight of the piston. Volume cannot exceed 100 cc of gas. An 1800 psi CO_2 cartridge replaces the gas cylinder.

Spaced Channels Form Nailable Flooring

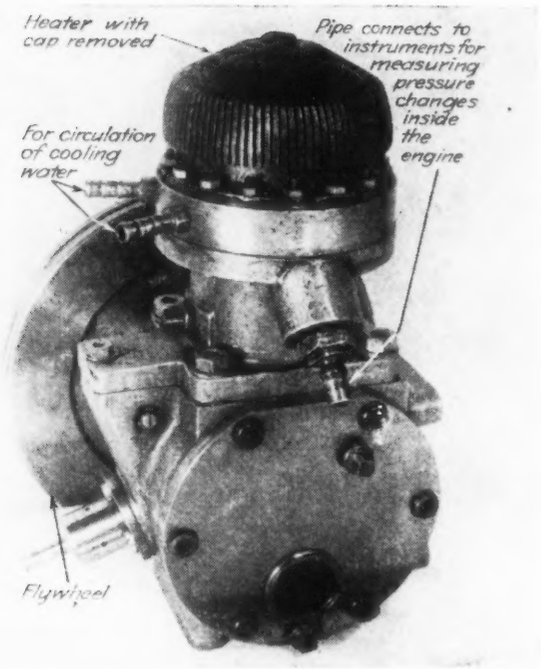
Nailable steel flooring, designed to cut maintenance costs for railway freight cars, trucks, and trailers and relieve the shortage of such hauling equipment, has been developed by the Great Lakes Steel Corporation, Detroit. The new flooring has steel channels between which nails can be driven. Nails, driven into grooves formed by parallel flanges of curved steel, are deformed and hold with about four times the strength as when driven into wood. Steel flooring will make a car usable for all types of lading throughout car life, as nailing will not damage the floor in any way. The 8-in. wide channels are laid across the width of the car and welded to the underframes for strength and durability.



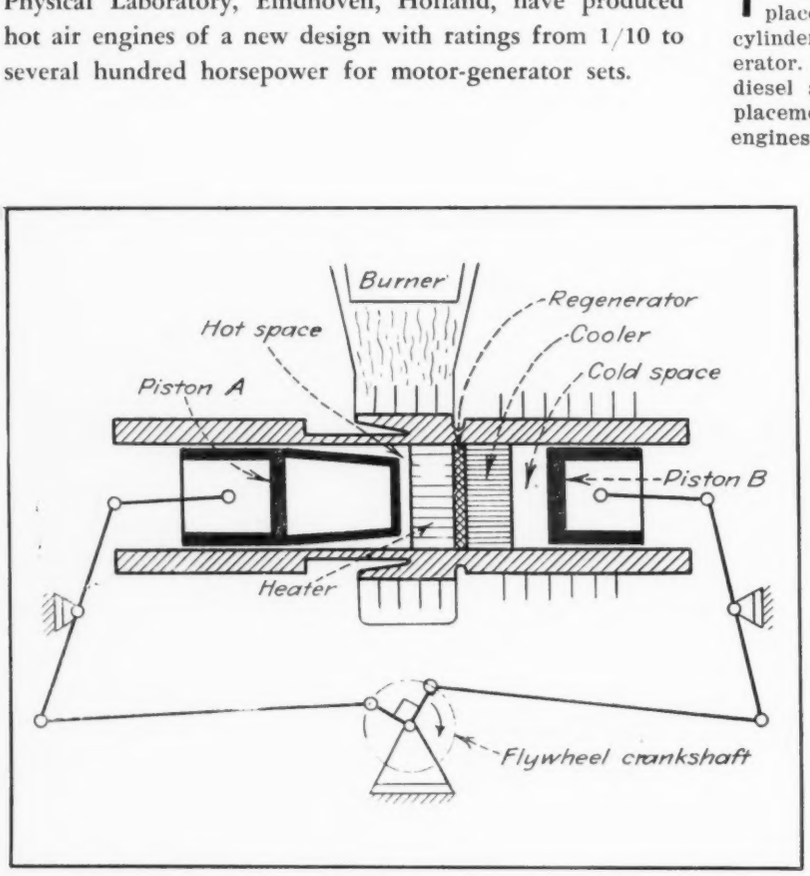
1 SPACE is left between channels for the nailing groove. Grooves are filled with a self-sealing composition that prevents loss of bulk freight, such as sand or grain. Greater strength of the channels enables lighter underframes. Other advantages are increased resistance to impact, non-splintering, non-absorbancy of liquids and ease of cleaning.

Piston and Displacer Combined for Practical Hot Air Engine

Of all the engine cycles ever conceived, the hot air engines have not been surpassed for their inherent efficiency, which is equal to that of the Carnot cycle. However, the low pressures of early hot air engines required unreasonable dimensions. Size, slow speeds and heat transfer problems resulted in abandonment of this prime mover. Scientists at Philips Physical Laboratory, Eindhoven, Holland, have produced hot air engines of a new design with ratings from 1/10 to several hundred horsepower for motor-generator sets.


Heater with cap removed
Pipe connects to instruments for measuring pressure changes inside the engine
For circulation of cooling water
Flywheel

1 **THE OLD** piston-and-displacer per cylinder is replaced by an arrangement using one piston per cylinder. Heat transfer is improved by a new regenerator. Efficiency is intermediate between that of diesel and gasoline engines. Power per unit displacement is greater than in internal combustion engines. This engine develops 15 hp at 3,000 rpm.



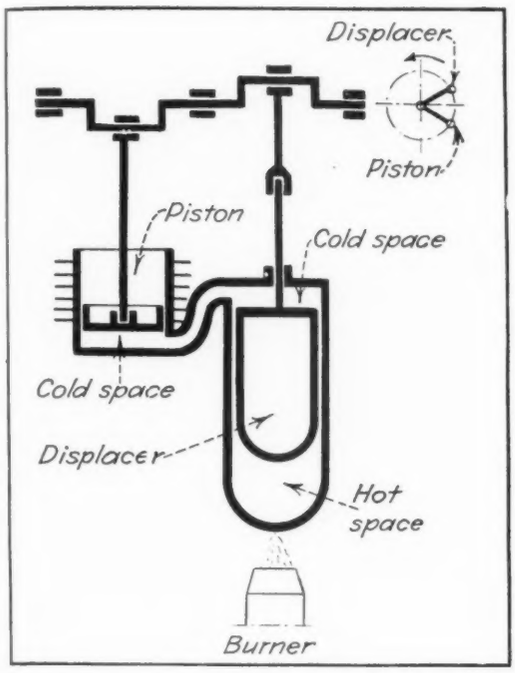
4 **THE PHILIPS ENGINE** combines piston and displacer in such a manner that only one cylinder per piston is required. Heat transfer is improved by a new regenerator; a sponge-like fabric of fine metal wire, through which air must pass in transfer between the hot and cold spaces. Each time the hot air is expanded, heat is absorbed by the regenerator. When cold air is returned after compression, 95 percent of the stored heat is given to the air.

Operating Cycle of the Philips Engine

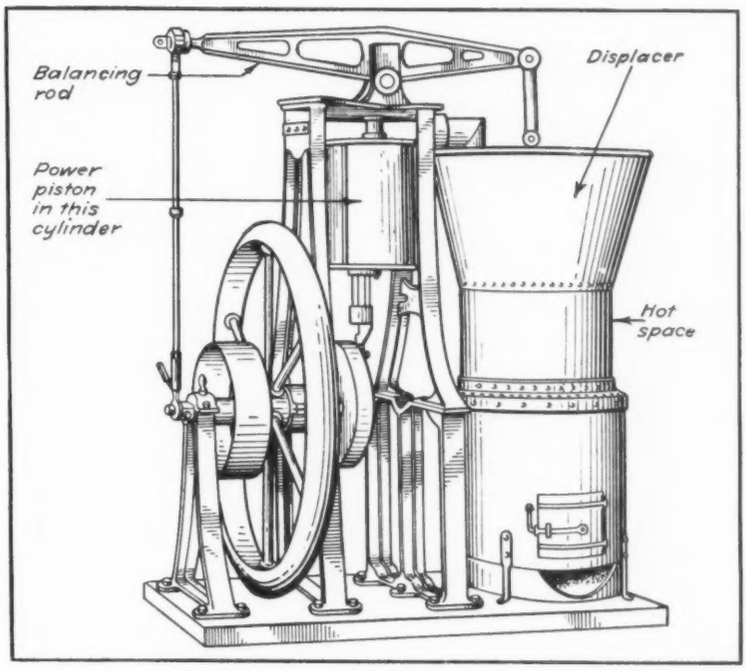
AIR IS HEATED in the engine from 100 C to 650 C in a fraction of a second during every cycle. The regenerator supplies ¾ of this heat, which otherwise would have to come from the burner.

Operation can be followed from the schematic. Compressed air is heated in the hot space; it expands and pushes piston **A**. Flywheel action then drives the expanded hot air through the regenerator, where the heat is absorbed, into the cold space. Cold air is recompressed by piston **B** and displaced into the hot space. This air receives the stored heat as it passes through the regenerator.

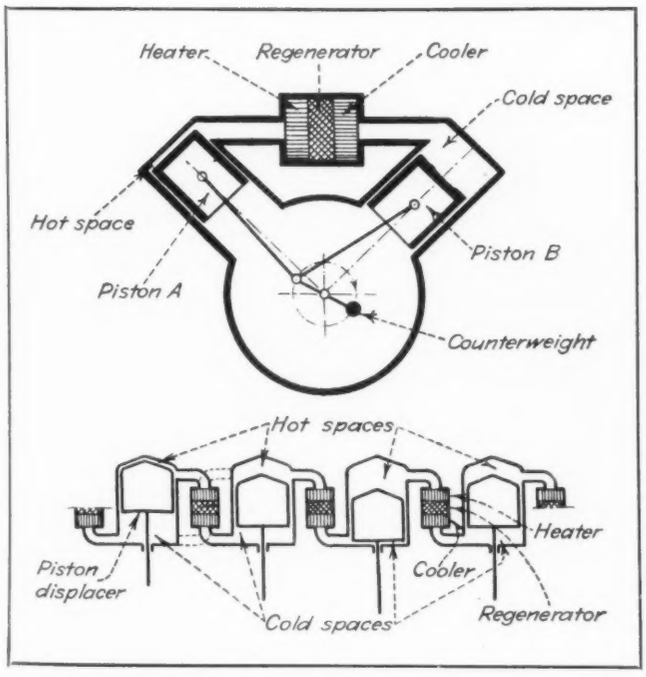
Meantime the heater, receiving heat from the burner, adds more heat energy to the air. Because combustion is external, fuel is completely burned and engine parts are cooler. There is no corrosion in the cylinder because temperatures are low and the air is clean The engine is quiet because there are no periodic explosions.



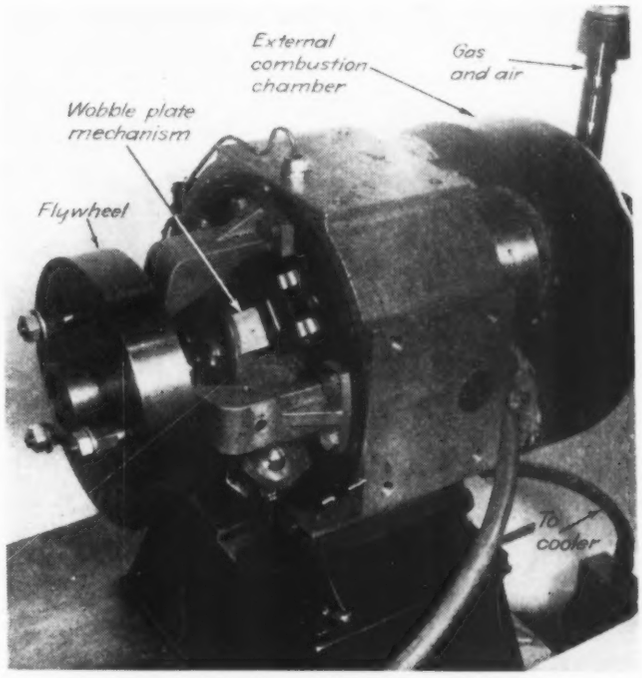
2 IN THE CLASSICAL DESIGN the flywheel carries the displacer down, forcing hot air into the cold space. Hot air then expands, forcing piston up. Energy thus put into flywheel is more than eough to drive piston down, recompressing the air in cold space and forcing it back into hot space for reheating.



3 PRINCIPLE OF THE AIR ENGINE was conceived by Stirling in 1816. With each revolution a quantity of air, or other gas, is heated, expanded, cooled and compressed. About 1850 Ericson built a 300 hp hot air engine for our Navy. Speed was 10 rpm with four, 14-ft dia pistons. The early engine shown deviates from the schematic in that the displacer in the top of the large cylinder is driven by a balancing rod instead of another throw on the crankshaft.



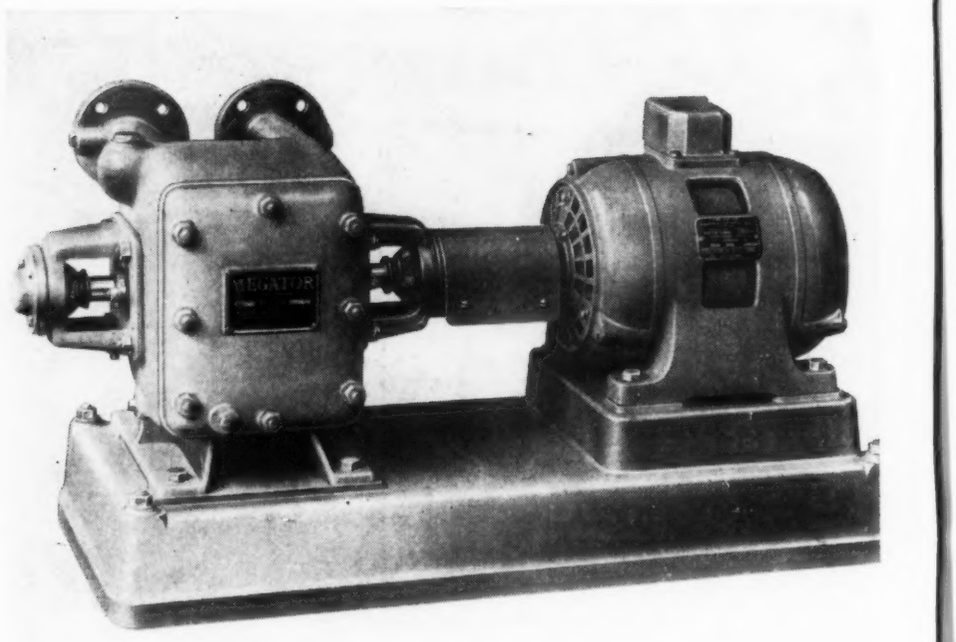
5 PRESSURES go to 50 atm and temperatures to 650 C in Philips engines. A V-type engine is shown schematically. A counterweight has been added and the driving linkage is simplified and balanced. The system is inclosed, and could be operated at elevated air pressure. The cooler operates on air or water to maintain the desired temperature differential between hot and cold spaces.



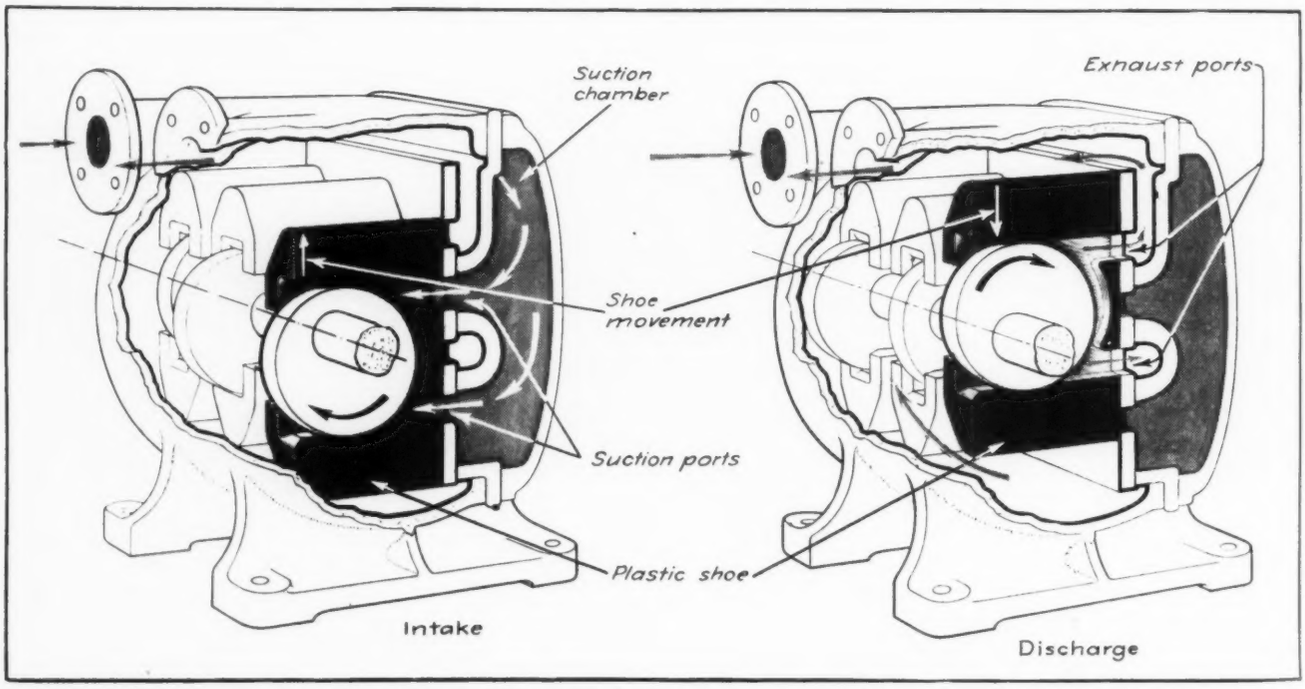
6 HOT SPACES are connected to cold spaces in series in the 4-cyl engine, shown with cover plate removed. Between cylinder block and flywheel, part of the wobble plate mechanism is visible. It transmits motions of the four horizontal pistons to the horizontal main shaft. The Philips develops high traction force at low speed, thus simplifying the gear requirement.

Pump Has Sliding Displacement Chambers

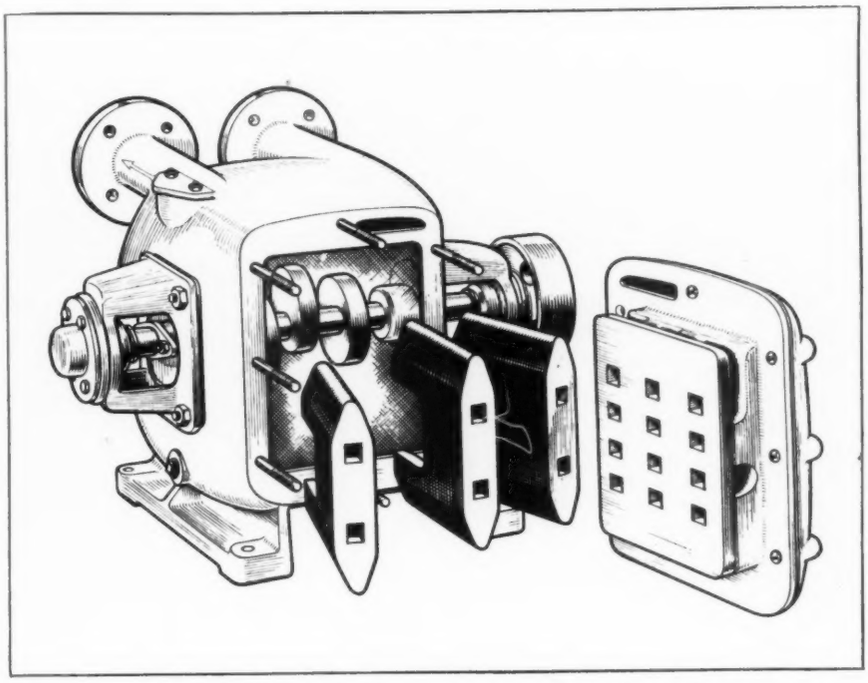
Unusual impeller design in the Megator self-priming pump gives constant volume and positive displacement without valves or metal-to-metal moving contact.

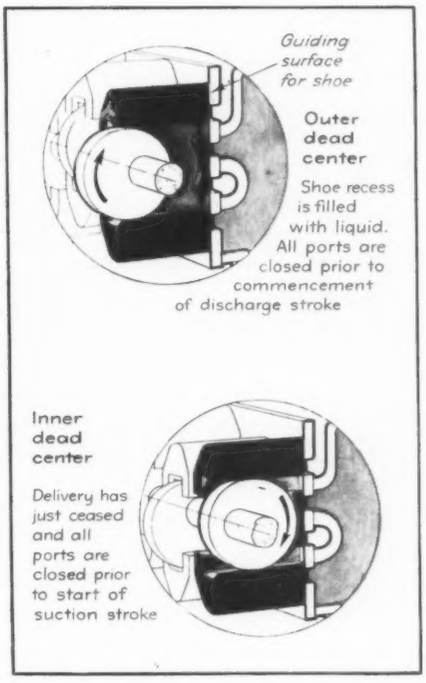


1 **THREE ECCENTRIC DISKS**, integral with pump shaft, develop suction and pressure as they rotate within individual displacement chambers. The chambers are forced up and down by camming action of disks, thus alternately aligning chamber ports with intake and discharge openings. Unfailing self-priming is claimed. Developed by Megator Pumps & Compressors Ltd., Feltham, Middlesex, England, these pumps have been successful in coal mines handling large quantities of air and water in various proportions, often mixed with coal and stone dust.



4 **THE ROTOR** is made of nitrided steel with three integral eccentric disks spaced 120 deg about the rotor axis. Downward motion of a disk lowers the shoe until intake ports in the suction chamber are aligned with shoe ports. As the disk rotates, its horizontal outward motion causes liquid to be drawn into the shoe. Continued motion carries the shoe up, sealing off intake ports. Further rotation aligns shoe with discharge ports and then expels liquid from the chamber into pump body, which is connected to the discharge lines. Suction chamber is formed between inner and outer side covers. The ball bearings that support the pump shaft are located outside of the chamber.



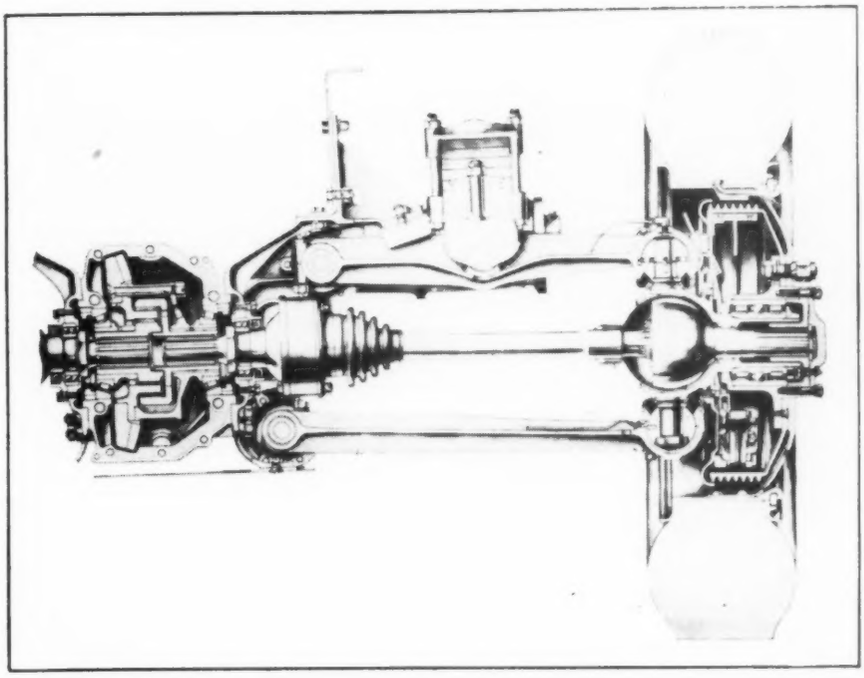

Guiding surface for shoe
Outer dead center
Shoe recess is filled with liquid. All ports are closed prior to commencement of discharge stroke
Inner dead center
Delivery has just ceased and all ports are closed prior to start of suction stroke

2 **REMOVABLE COVERPLATE** permits pump inspection without breaking any pipe connections. Self-aligning ball bearings are located in separate brackets, away from the sealing glands. The Megator pump is made in sizes up to 100 gpm and for 65 psi working pressures. Capacity, varied by altering the speed, is approximately constant at any pressure within the working range. Flow is steady because of high frequency and small amplitude of stroke. Pumping pressure holds the shoes against the cover plate during operation.

3 **THE SHOES** are rubber, stiffened by light alloy insert. Faces are phenol formaldehyde with asbestos filler bonded to the rubber. Delivery pressure closes the shoes on the rotor, thus automatically compensating for wear of the disks.

Heavy Duty Military Truck Suspension

German military vehicles exhibit some unusual constructions. This driving axle arrangement was used on a heavy reconaissance car. Ball joints and anti-friction bearings are widely applied. The spring seat location is unconventional.



1 **ONE** of four driving and steering axles is shown in cross-section. The vehicle spring seat is swivel-mounted on the upper parallel arm. Ball thrust bearings support a ball-joint mount for the stub axle. A unique type of bearing is used to support the wheel. The bearing is a combination ball and roller type. One row of balls is placed between two rows of rollers. Constant velocity universal joints are mounted on splines on each end of the axle drive shaft.

Important Considerations In Charpy and Izod Testing—I

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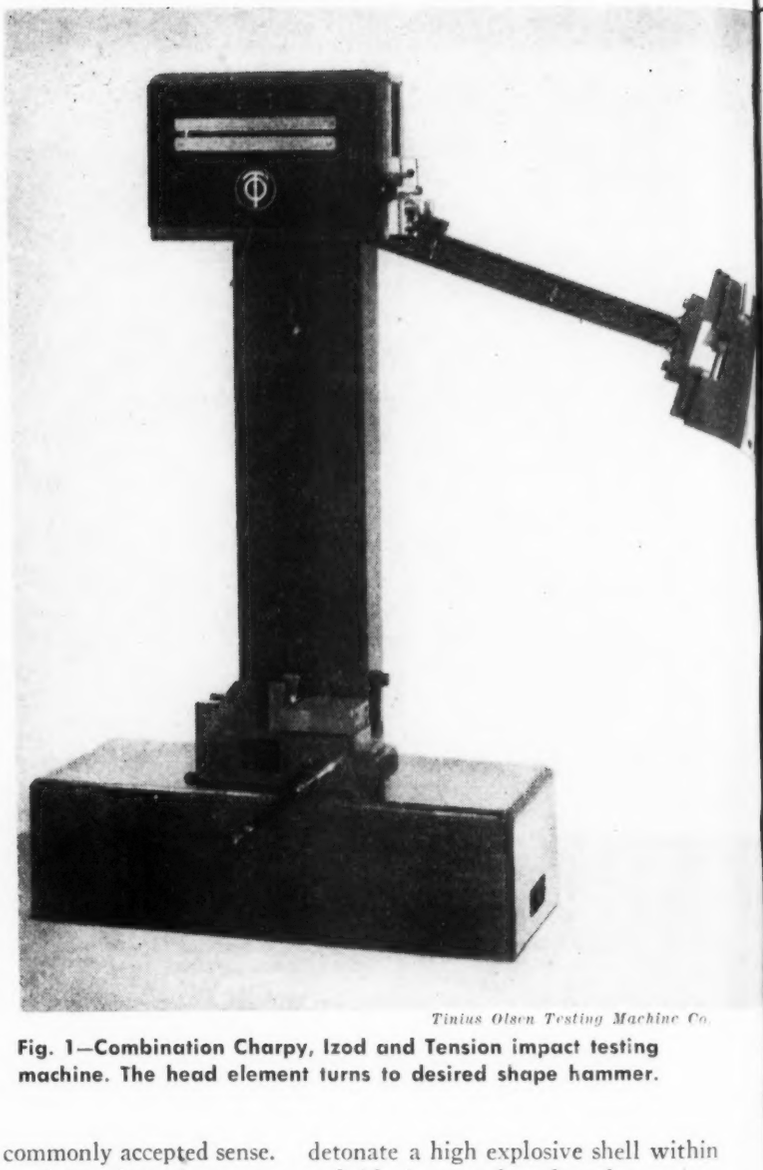
The need for impact tests with a discussion of the Charpy and Izod types. Gives details of the various types of standard test specimens and the advantages of each. Discusses conditions necessary for accurate testing results.



Tinius Olsen Testing Machine Co.

Fig. 1—Combination Charpy, Izod and Tension impact testing machine. The head element turns to desired shape hammer.

CHARPY AND IZOD tests, as well as various special impact tests, have for many years been subject to investigation by metallurgists, physicists and design engineers. Except in certain noteworthy fields, such as low temperature applications, the use of these tests in specifications has lagged behind technical knowledge, probably partly as a result of the difficulty of interpreting and applying impact test data to specific design applications.

Since the striking velocity of the pendulum hammer used in the Charpy and Izod tests is of the order of 16 ft. per sec., the adjectives "impact," "shock" and "dynamic" give an inaccurate impression. But, because these terms are generally used to distinguish such tests from the "static" or tensile tests, these phrases will be used in their commonly accepted sense.

Many types of tests have been employed to measure the resistance of materials to impact. Aerial bomb bodies, carrying a dummy charge, have been tested by dropping them from an airplance upon concrete, armor or bed rock. This type of test gives good results because it duplicates service conditions, but because it is destructive, it is wasteful of material. A variant of this test is one wherein a known weight is dropped on the fabricated part undergoing test. Interpretation of this test is less direct, and again the part is damaged.

An example of a dynamic test on small samples, in which actual service conditions are approximately simulated, is the explosive test used by the Germans during the recent war as an acceptance test for gun forgings. Prior to the development of this test, it was German procedure to detonate a high explosive shell within a finished gun tube selected as representative of a manufacturer's practice. If the tube shattered, instead of bulging or peeling like a banana, the entire lot of tubes was subject to rejection. This was a direct test comparable to the bomb-dropping test and was wasteful of material. A later modification involved exploding the shell in a prolongation of the gun tube so that the damaged portion could be removed and the tube salvaged. End point of this development was reached however, by trepanning a small cylinder, about one inch in diameter, from the end of the gun forging, boring it to produce in effect a miniature gun tube and detonating a carefully weighed explosive charge within the specimen. Acceptance or rejection was based on the manner in which the specimen withstood the explosion.

These special tests are useful but

*The statements and opinions expressed are those of the author and do not necessarily reflect the views of the U. S. Army Ordnance Department.

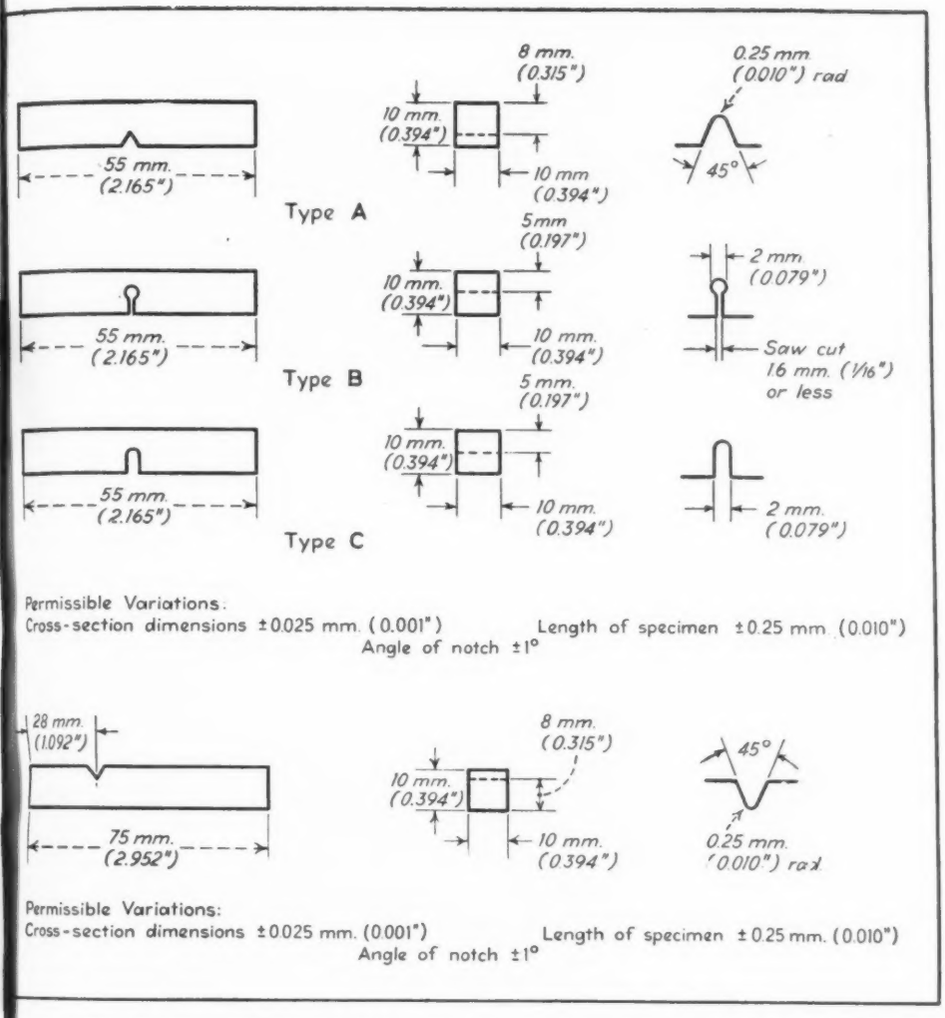


Fig. 2—Standard impact test specimens as prescribed by A.S.T.M. Specification E-23-41T. Three types of Charpy specimen, top; one Izod specimen, bottom.

are inadequate because they do not indicate to what degree the product met, or failed to meet, requirements. The manufacturer can tell neither how much he must improve his practice if the part failed, nor how much he might be able to effect economics in manufacture, if the part met the test successfully.

The standard tests, such as the Charpy and Izod, can be applied to materials to be used for widely different applications. Since the test results are reported in terms of energy absorbed by a standard specimen, these tests give numerical measurement of the degree of success or failure.

Using the same principle of energy absorption, determined by the height of impeded swing versus free swing, Charpy and Izod tests are handled differently. The most important difference between the tests is in the manner of supporting the specimen. The Charpy specimen is laid on two, parallel anvils with the notch centered and facing away from the pendulum; acting as a simply-supported beam with the load at the center. The Izod specimen is held in an upright position by a vise; acting as a cantilever beam with the load at the free end. The notch, facing the path of the dropped pendulum, is even with the top of the vise.

Because of this significant difference in applying the load, true correlation between the tests does not exist. Numerical results below 30 ft.-lb. are often in reasonable agreement, but specification requirements should not be translated from one type of test to the other.

If an impact test is desired at a temperature different from the ambient, the Charpy test is generally used. The most important reason for this is that the Charpy specimen can be mounted in test position much more rapidly than the Izod. Another reason is that the notched region of the Charpy specimen is not in contact with the heat-conducting metal of the testing stand. A skilled operator can complete a Charpy test with the loss of only a few degrees from the temperature of the bath.

Test Specimen

Test specimens recognized at standard by the American Society for Testing Materials, A.S.T.M. Specification E-23-41T, are shown in Fig. 2. Not standard, but also popular is a round Izod specimen which has the advantage of being economically produced in a lathe, although the notch, not being circumferential, must be milled or ground. Considerable resistance to the adoption of the Charpy or Izod test for routine inspection purposes has been experienced because the four-square specimens are expensive and time-consuming to prepare.

The British customarily use the Izod test, while on the European continent several specimens which closely approximate Charpy standards of the United States are used. The most used foreign specimens are shown in Table I.

It will be noted that the chief variant in the various Charpy speci-

Table I—European specimen specifications for Charpy-type test

Type of Specimen	Length	Width	Depth	Notch
Mesnager (French).....	55 mm.	10 mm.	10 mm.	2 mm. wide, 2 mm. deep, 1 mm. radius
DVM (German).....	55 mm.	10 mm.	10 mm.	keyhole, 3 mm. deep, 1 mm. radius
DVM (Special, German).....	55 mm.	10 mm.	10 mm.	45° notch, 3 mm. deep, .05 mm. radius

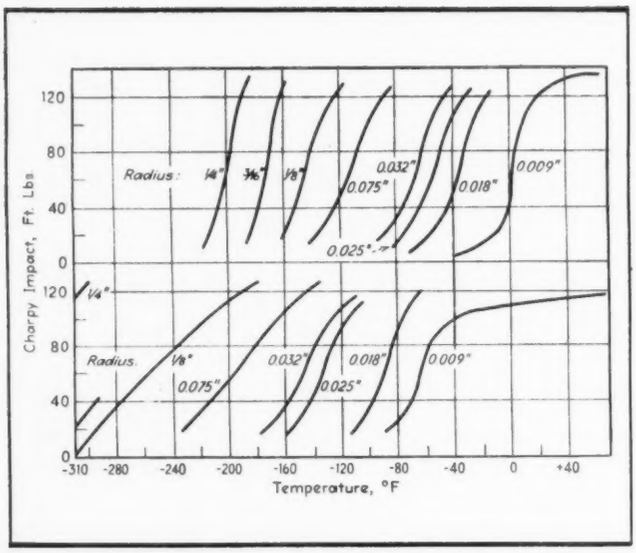


Fig. 3—Notch radius effect upon the Charpy impact properties of two steels: A carbon steel, top; and a 2 percent nickel steel, bottom; each having 0.15 percent carbon and both heat-treated by normalizing. After Armstrong and Gagnebin.

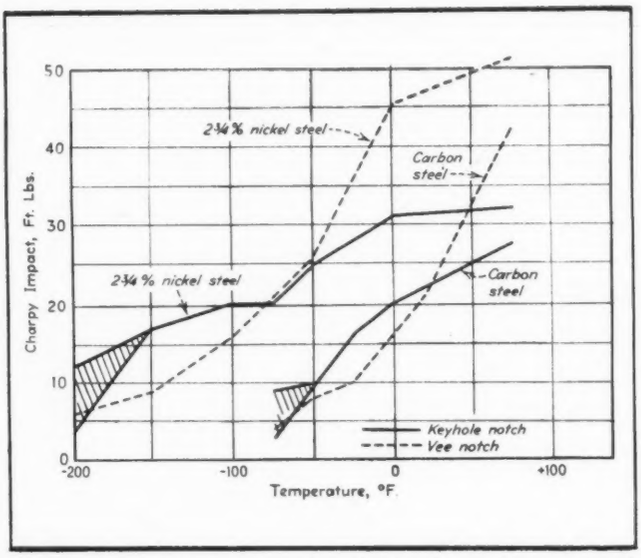


Fig. 4—Comparison of results obtained on Charpy specimens with V-notch and Keyhole notch on two steels both normalized and drawn, and containing 0.18 percent carbon; one having nickel. After Armstrong and Gagnebin.

mens is the shape of the notch, particularly the radius at its root. The importance of this radius is great, as shown, for two steels in Fig. 3. As the root radius is decreased, the testing temperature at which a sharp drop in Charpy values occurs—called the transition temperature range—increases. For some steels this transition range may be at room or even elevated temperatures. Therefore a sharp notch, by imposing more severe stress concentration upon the test area, provides more exacting conditions for revealing tendencies toward brittle behaviour.

The difference in results which may be obtained with the standard V-notch and keyhole notch Charpy specimens is well illustrated by Fig. 4. At room temperature the keyhole values are lower than the V-notch values simply because the former specimens possess less cross-sectional area of test material below the notch. As the testing temperature is decreased, the V-notch values decrease the more sharply until a temperature range is reached in which the V-notch specimens actually give lower values than do keyhole notch specimens. In this range the effect of stress concentration is the dominating factor, serving to obscure the differences in cross-sectional area. At very low temperatures, brittle behaviour is so severe that all differences between types of specimen are minimized and values become approximately alike. The keyhole notched specimen is generally used for commercial acceptance testing of materials to be employed at low temperatures.

From the practical standpoint of specimen preparation, it is not easy to choose between the two types of notches. The keyhole is produced by drilling and slotting; which gives little chance for developing an incorrect radius at the bottom of the notch. Since scratches produced by the notch drill are in a harmless direction they will not cause stress concentrations. However, difficulty is experienced in drilling materials of relatively high hardness and the use of a jig does not entirely prevent drifting. The V-notch must be milled or ground. Considerable time may be saved by gang milling; cutters must be kept dressed to the correct radius. Siemen, in *A.S.T.M. Bulletin,* March, 1946, proposed a fly cutter, essentially a milling cutter with a single tooth, to alleviate this difficulty.

The presence of scratches at the root of the V-notch has been believed by some to influence results by encouraging high local stress concentrations. To circumvent this it has sometimes been practice to polish the root of the notch with a fine abrasive and a taut piece of revolving piano wire. The results of a series of tests on four steels, each at a different level of impact resistance, are shown in Table II to afford comparison of the effectiveness of polishing the base of the notch. These data indicate that essentially no effect results from polishing, either in reducing the scatter of results or changing the average level of values obtained. This suggests that the presence of scratches is of little or no importance to the results.

Large variations in test bar cross section give interesting results. It would seem logical to expect that a bar twice as wide as standard would require twice the energy to break. That this is often a fallacy has been shown by the work of Moser, in *Transactions,* Manchester Ass'n of Engineers, 1937-38, some of which results are incorporated in Fig. 5. As the width of the bar was increased in this series of tests, the energy of impact increased proportionately to a certain point; there was then a sudden decrease in the amount of energy absorbed to such an extent that a bar three times as wide as standard required less energy for rupture than needed for the standard bar. The point of this departure from proportionality differs in different materials. For some it may not occur within any practical limits of bar size. The reason for the effect is to be found in the distribution of stresses in the test piece. The wider the bar, the greater the restraint imposed upon plastic deformation and hence the greater tendency for brittle behaviour. In materials liable to brittleness, such as those in which the transition temperature

occurs close to room temperature, increased width of the bar will result in behaviour similar to that shown by the steel of Fig. 5. Steels that retain toughness at subzero temperatures may not show a tendency toward brittleness at all.

The above discussion can be translated into terms of sub-size test pieces as well. A bar that is half standard in width or thickness will not necessarily absorb half the energy required to rupture the standard bar. It is more difficult to induce brittle behaviour in such a test piece, therefore results secured on sub-standard bars may occasionally give an impression of toughness which would not be substantiated by standard tests. This factor is sometimes a serious limitation upon using the Charpy or Izod test for inspection testing when the bar or plate size is not large enough to permit procuring a standard specimen. Sub-size specimens may be used only if a comparative set of values is established for the dimensions decided upon; these values may or may not bear a relationship to results on standard size bars.

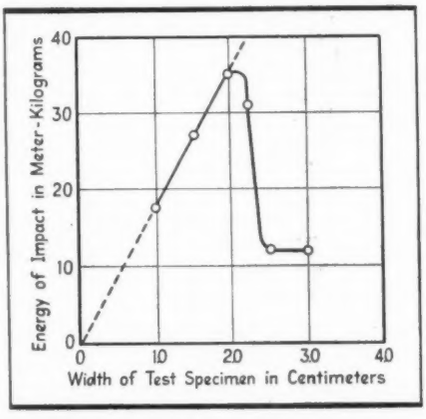


Fig. 5—Effect of widening the test specimen upon the total energy absorbed during impact test; annealed 0.43 percent carbon steel. After Moser.

Under certain circumstances, the quality of the material may greatly influence results. For example if test is made of a specimen from a severely laminated steel plate with the notch parallel to the top face, rupture may develop in a discontinuous path as successive laminations are encountered and breached by the crack. The net result may be likened to a test of a composite specimen, only the top portion of which is influenced by the notch. The fracture has a typical woody appearance, the laminations are generally opened, and the resulting impact energy value is unusually high. There is the anomaly of poor material yielding higher values of energy absorption than quality material. Results may be highly erratic. To minimize this effect the notch may be placed at right angles to the planes of lamination, as in the schematic sketch of Fig. 6, which forces a clean break.

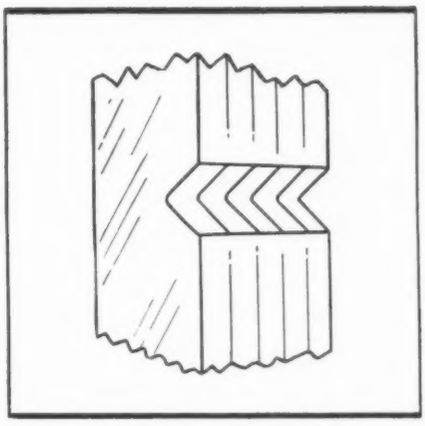


Fig. 6—Diagram showing preferred notch position in laminated materials.

Testing Conditions

A factor often overlooked in impact testing is the temperature of the specimen at the time it is broken. In tensile or hardness testing of steels this is relatively unimportant. Reference to Fig. 4 will show, however, that a difference of a few degrees in test temperature can produce significant change in the level of Charpy energy, even at room temperature in the case of the carbon steel. With the V-notch this sensitivity to temperature may be particularly high, as previously pointed out. Since shop temperatures vary, it is important to record the temperature at the time of test or to make the test at the same arbitrary temperature. This does not require complicated apparatus. A pail of water of the proper temperature, in which the specimens may be immersed for 15 to 20 min., is sufficient.

As mentioned in the introduction, a great many erroneous impressions exist regarding the speed of application of the load in the Charpy and Izod tests. This speed is actually in the neighborhood of 16 ft. per sec.; slow enough that the Charpy and Izod tests may be considered simply translations of a notch-bend test in which the load is applied by a moving pendulum instead of the head of a tensile machine. Increasing the speed of loading has an effect somewhat similar to that of lowering the temperature of the test. In other words, increasing the speed shifts the transition temperature to a higher range.

Part II of this article, discussing types of test machines, reproducibility of results, significance and application of tests, will appear in the November 1947 issue.

Table II—Comparison of Charpy V-Notch Test Results to Determine Effect of Polishing the Notch

Test No.	Series 1		Series 2		Series 3		Series 4	
	Polish	Unpolish	Polish	Unpolish	Polish	Unpolish	Polish	Unpolish
1	17½	19½	54½	55½	77	77½	85½	84½
2	18	20	56½	56½	77	78	87½	87
3	18	20½	56½	56½	79	79	89	89
4	18½	20½	58	57½	79½	79	89	89
5	20½	21	58½	58	81	79½	89	91
6	21	21½	58½	58	81	80	89	93
7	22	21½	59	59	81	81	90	94
8	22	22	60	59½	83	81	97	95
9	22	22½	60	60	83	82½	99	96
10	23½		60	60	83	87	102	101
Avg. Ft. Lb.	20½	21	58	58	80½	80½	91½	92
Total Spread	6	3	5½	4½	6	9½	16½	16½
Rock. C Hard.	40½-43½		32-34		24½-27½		18½-20½	

REFERENCES

Armstrong and Gagnebin "Impact Properties of Some Low Alloy Nickel Steels at Temperatures down to —200°F." *Trans. A.S.M. Vol. XXVIII*, 1940.

S. E. Siemen, *A.S.T.M. Bulletin*, March 1946.

M. Moser "The Development and Present Position of Continental Research on the Notched Bar Impact Test," *Trans. Manchester Association of Engineers* 1937–38.

Progress IN REVIEW

PLASTICS

Resin-bonded laminated wood, four-ply white oak, is now used in making liquid holding barrels. These barrels, as mentioned in *Plastics,* August 1947, are less expensive than whiskey-grade non-laminated barrels and are 20 lb lighter. They are less subject to leakage because of variation in temperature or humidity, and have high impact strength. The barrels have been tested by filling them with 300 lb of water and dropping them 12 ft; they survived the test while old-style barrels burst. The inside of the barrels can be coated with various materials.

High-frequency heat-sealing units on the market today are reviewed in the August 1947 issue of *Modern Plastics.* Practical advice is given to facilitate the purchase of the unit best designed for a given type operation. Initial and operating costs are compared; types of power supply, oscillator and output circuits are mentioned.

Several new plastic materials have recently become available in large quantities. Tenite III, cellulose acetate propionate, is now supplied by Tennessee Eastman Corp. in a variety of colors for injection molding or extrusion uses. Though costing five cents more per pound, according to *Plastics World,* August 1947, this new material is superior in many ways to both Tenite I and II. It has better dimensional stability and impact strength, and does not have an offensive odor. Celanese Plastics Corp. offered the first cellulose propionate molding powder late in 1945, but, as mentioned in the August 1947 issue of *Modern Plastics,* availability of this material has been poor because large-scale production was so long delayed. Three types of vinyl ethers, as reported by the same magazine, are being produced by the Carbide and Carbon Chemicals Corp. These materials can be polymerized to liquids, waxes or rubbery solids, or can be used in general chemical synthesis. The polymers have already achieved considerable fame in Germany as pressure sensitive adhesives and, via copolymers, as modifiers, plasticizers for rubber surface coatings, etc. The B. F. Goodrich Co. now offers vinyl resins specially formulated for easy production of the vinyl pastes, or organisols, already widely used in Germany and England. The use of these pastes reduces costs for coating, dipping, molding and casting. In many instances, expensive inflammable solvents have been made unnecessary. Single-pass operations are sufficient to produce a film of any desired thickness; pre-paste techniques often required several passes with drying time between each pass. The Rohm and Haas Co. has introduced Plexiglas V, a new acrylic injection molding powder. As mentioned in *Modern Plastics,* August 1947, this material possesses higher heat distortion limits, better moldability and lower shrinkage values than previous types. The most recent polystyrene improvement, announced by Monsanto Chemical Co., gives a material with high heat resistance, it can be cleaned by boiling; and high flexural and impact strength.

Molded resin-fabric bearings have been used in place of white metal bearings in a British steel company's works. After using the resin-fabric bearings for a period of ten years, the following interesting facts were noted in *Plastics* (London), July 1947. The fabric bearings have a lower initial cost, last two to three times longer, require only 1/5 the time to replace, eliminate the need for the ton of grease previously used per week, save 19 percent in power consumption, are cleaner to use and less subject to cracks.

Flow characteristics of plastic molding powders have been thoroughly investigated in Canada. Flow-pressure relationships are presented for three types of crystalline filler, according to the August 1947 issue of *Industrial and Engineering Chemistry,* in several high polymer binders and with filler contents between zero and 75 percent. The data were obtained on an experimental extrusion press used as a viscometer to yield results in cubic centimeters per minute. In most cases the log of flow increased linearly with increased pressure. The finest fillers gave the greatest increase in viscosity and the closest approach to theoretical densities. The fillers included organic compounds and sand; the binders included polyvinyl acetate, nitro-cellulose, condensed dibutylsebacate and butyl rubber.

Softeners for us in passengers and truck tires have been compared by field tests of 2½ million miles. As mentioned in the July 1947 issue of *Rubber Age,* all the softeners used were acceptable on the basis of these tests, though noticeable differences were observed. Laboratory tests confirmed the belief that 5 percent petroleum unsaturants gave the best and medium hard asphalt gave the worst results.

Tear resistance of vulcanized natural rubber has been compared with those for synthetic rubbers by G. Reinsmith in the July 1947 issue of *India Rubber World.* The factors involved include: depth of nick, number of nicks per specimen and temperature of test. With no nicks, or shallow nicks, natural rubber is superior; with deep nicks, synthetic rubbers proved better. In general it was found that better tear resistance was obtained in materials with high tensile strength and low hardness.

Automobile tires and inner tubes are being improved all the time. Great Britain is beginning to produce tubes made of butyl synthetic rubber because of their high air retention properties. One of the large American tire manufacturers, also mentioned in *India Rubber World,* June 1947, has developed a tube for buses, trucks and passenger cars that is said to be very safe. These tubes are really inner tires with two air compartments. The outside compartment holds 1/3 of the total air. When the tube blows, the outer section collapses but the inner compartment will support the load of the vehicle until it can be brought to a safe stop. Another manufacturer has used

a similar idea in building airplane tires. These tire-like tubes weigh 125 lb. and have an outside diameter of 63 inches. A premium passenger car tire, made with neoprene synthetic rubber, is said to outwear ordinary rubber tires by as much as 100 percent. The longer tire life is attributed to neoprene's greater heat resistance which permits a 60 percent thicker tread.

NONFERROUS METALS

Zirconium and titanium are being studied by various research activities with increasing interest. Titanium, the fourth most plentiful metal according to W. H. Waggaman and E. A. Gee of the Bureau of Mines, is lighter and stronger than steel and has good resistance to corrosion. It can be rolled into bars and sheets or drawn into fine wires. Titanium is produced by the reaction of liquid titanium chloride on molten magnesium. The resulting product is baked, ground and sintered before being rolled or drawn.

Coiled aluminum sheet is being substituted for galvanized steel in fabricating air ducts for home and industrial applications. The aluminum is being used, as reported in *Steel*, July 7, 1947, because of its low cost, light weight and good resistance to corrosion. The material used, generally 2S ¾H, will readily take any type of mechanical interlocking joint form, including the Pittsburgh lock seam. Some shops do not mallet the Pittsburgh lock seam completely shut because it may be necessary to open the seam during assembly. The 2S ¾H alloy may crack under repeated working. Riveting, welding and spot soldering techniques are also used in assembling.

Magnesium alloy sheet is usually heated to at least 450 F before it is deep-drawn, but the alloy AM_3SO, manganese - calcium - magnesium, has been successfully drawn at room temperature. The drawing operation was performed in a series of intermittent steps, as reported by L. A. Carapelter and W. E. Shaw in *Metals Technology*, April 1947. Using 0.072 in sheet, it was found that the maximum drawability was about 25 percent for normal methods. Drawability over 40 percent was possible when the part was formed by intermittent operations. In general, the drawing was carried out in from 10 to 30 stages, but the lower number gave satisfactory results.

Bauxite, used in the production of aluminum, is still the most economical raw material from which to produce this light metal. Investigation has been underway for four years in an effort to produce raw materials, equivalent to bauxite, from kaolin clay. Kaolin clay is available in unlimited domestic quantities, but the best method of processing, produces a material that costs twice as much as bauxite. The Hoffman process, named after its developer, J. I. Hoffman, was started during the past war. In this process, the clay is roasted, digested with dilute hydrochloric acid and the insoluble silica is removed by filtration. Upon the addition of hydrochloric acid gas, a hydrated aluminum chloride is obtained from which alumina is obtained after drying and roasting. The hydrochloric acid is recovered for reuse and the alumina is treated in the conventional manner.

Fires occurring during the heat-treatment of magnesium, at temperatures well below the melting points, have been carefully investigated. It was found, C. B. Willmore and W. S. Peterson, *Materials and Methods*, July 1947, that the ignition temperature of sand cast AM265 and extruded AM3S were both lowered by increased moisture content in the furnace atmosphere. Accidental contact with other metals, under conditions which may permit the formation of low melting constituents, as well as the presence of slivers, sharp edges or thin sections that may become locally overheated were also found to be causes of fires. Very small amounts of combustible organic materials have been found equally hazardous.

Cast aluminum fixtures can be chrome plated by a recently developed commercial process. A new plant has been constructed, as mentioned by A. R. MacPherson, *Light Metals*, June 1947, that is capable of handling 1,500 units per day per shift. The castings are heat-treated to improve the adherence of a light copper plate. The parts are degreased, first with kerosene and then with trichlorethylene and steam, before being immersed in the plating baths. The baths are held in wax-coated neoprene tanks. After the first copper plating, the parts are given a second and heavier copper plate at high current density. A thin coat of nickel is plated on the copper, followed by the bright chromium finish.

Tin plating bath efficiencies are said to be markedly improved by the addition of 0.1 to 10 percent of sodium, or potassium, to the anode, according to a British patent recently granted. The amount of alkali added depends on the current density. It is said that 0.1 percent is satisfactory for low current densities but at 100 to 150 amp/sq ft, about 5 percent of sodium or 4 percent of potassium is required. The anode efficiency is then as high as 99 percent, whereas normal plating salts gave an efficiency of only 64 percent at 75 amp/sq foot.

High-purity magnesium anodes can be successfully used to protect lead-covered communication and power cables from galvanic corrosion, according to laboratory and field tests reported by R. L. Featherly, *Electric Light and Power*, April 1947. In practice, three types of anodes, weighing 16, 52 or 60 lb, are used. For water filled ducts, the anodes are frequently installed in the manholes but for buried cable the best practice is to place the anodes in holes approximately 10 ft from the cable. The holes should be back-filled with a mixture of bentonite clay and gypsum, with some added anhydrous sodium sulphate when high resistance soils are encountered. Properly installed, such magnesium anodes will have a life of approximately ten years.

Aluminum alloy castings are being used for thermally stressed parts of cooking stoves and ranges because of a shortage of iron castings. As noted in the July 1947 issue of *Light Metals*, the use of such castings was restricted to nonthermally stressed members prior to the war, because, as a result of poor design, thermally stressed parts twisted. These aluminum alloy parts are now used for burners and hot plate spiders. After 12 months use, no appreciable change has occurred. The parts have been made both by die-casting and permanent mold casting methods.

An all-magnesium, two-place aeroplane is currently under construction by a Britsh plane manufacturer. The plane will have, according to *Light Metals*, July 1947, either a fixed or retractile undercarriage. The 925 lb. low wing, single engine monoplane will be able to carry a dead load total of 669 pounds. Light as it is, this aircraft will be capable of a cruising speed of 125 mph at an altitude of 1,000 feet.

Aluminum and copper have been added to some experimental extruded zinc alloys, made with high purity zinc, to discover their effects on the mechanical properties of the final material. In addition to the aluminum and copper, small amounts of magnesium, manganese, lithium, silver and other alloying elements, were included. As mentioned by A. S. Kenneford, *Journal* of the Institute of Metals (British), March 1947, cadmium, antimony, silicon and bismuth were either detrimental or had no effect. Lithium could be used to replace magnesium in some of the alloys

but there was no advantage in such a substitution. Nickel and manganese produced alloys of higher tensile strength but lower ductility, while silicon produced an increase intensile strength with no loss in ductility. Alloys ranging in tensile strength from 21 to 70,000 psi were obtained but these alloys had rather low impact strength compared to those of the 60-40 brasses. Alloys of promising commercial application have the following percentile additives: 4.0 Al, 0.05 Mg; 4.0 Al, 0.4 Cu, 0.05 Mg; 4.0 Al, 0.05 Mg, 0.05 Mn; and 4.0 Al, 4.0 Cu, 0.05 Mg, 0.05 Mn, and 0.05 Nickel. In case of a copper shortage, some of these alloys might be used in lieu of the brasses.

IRON AND STEEL

Spring materials must be chosen carefully when the applications involve either elevated temperatures or corrosive atmospheres. Hardenability sufficient to secure full hardening for martensite on quenching is the prime criterion for ordinary service. It should be remembered, as mentioned by F. P. Zimmerli, *Steel,* August 11, 1947, that the required hardenability goes up as the size of section increases. Cold-drawn steels are preferred over hot-rolled stock to form coil springs because the surface is better. For small-section springs, 1065 to 1095 steels are used. For larger springs, and springs that will stand elevated temperatures, 6150, 8660, 9260 or a 1½ percent Si, ¾ percent Cr steel are used. For very high temperature applications, springs of high-speed steel are required. Stainless steel, beryllium copper and various nickel alloys are used for springs in contact with corrosive conditions.

Wear-resistant surfaces, produced by carburizing, cyaniding or nitriding, add appreciably to part dimensions. In the manufacture of precision parts, undersize allowance must be made for this growth so that grinding and lapping operations can be minimized. Length and diameter changes during nitriding are discussed by L. J. Spencer in the June 1947 issue of *Steel Processing.* Four-inch speciments, nitrided for 60 hr at usual temperatures, grew 0.0015 to 0.0035 in. when the initial condition of the nitriding steel and the details of the process were adjusted to produce adherent, spall-resistant coatings. A similar range of increases was found in the diameters of ¾ and 1 in. rounds. The penetration of hardness from a surface of 1000 Vickers down to 800 Vickers would be about 0.015 in., a deeper case than that for the usual 48 hr treatment. The surface should normally be lapped to a depth of about 0.0015 in. to remove the brittle, white layer at the surface. A similar study by J. E. Erb and D. M. Woolf, reported in the June and July 1947 issues of *Steel Processing,* concerned cyanided, light case, and carburized, heavy case, hollow cylinders of C-1021 steel. The samples were carburized 12 hr at 1,650 F, box-cooled, reheated to 1,475 F, brine-quenched and submitted to 350 F temper. The cylinders were 1½ in. high and either 6 in. rized, heavy case, hollow cylinders of OD, 3 in. ID; or 3 in. OD, ¾ in. ID. The height of the cylinders increased by about 0.005 inches. The large specimens' OD's grew from 0.004 to 0.009 in., while the ID's got smaller by 0.008 to 0.017 inches. The inside of the cylinders assumed an hour glass shape; the ID at the middle remaining closer to the original dimension than the ID's at the ends. To find additional information about the C-1021 carburized steel, it was studied in another manner. For Charpy impact tests, samples were cyanided at 1,560 F for 2 hr and oil-quenched at 300 F to give a light case of 0.02 inches. Other specimens were carburized for 3 hr in the same manner as the dimensional specimens, to give a case depth of 0.03 inches. Unnotched Charpy specimens, with the light cyanide case, gave a range of values of 60-65 ft.-lb, or a value near 3 foot-pounds. Notched Charpy specimens, notches made before cyaniding, of either $\frac{1}{16}$, $\frac{1}{32}$ or 1/100 radius, keyhole or V, invariably gave values from 2 to 4 foot-pounds. With the carburized case, all the samples gave results in the 2 to 3 ft-lb range.

Forming of sheet metal becomes difficult when making complex shapes by drop hammer or press action. It is hard to maintain a constant metal thickness for all sections of the part. In elevated temperature applications, any thin spot will become overheated and can cause distortion of the assembly. It is important that forming dies be designed on the basis of the natural flow lines of the part instead of on arbitrarily established contours of the necessary, successive dies. Stretching and thin spots can be avoided, as described by C. O. Herb, *Machinery,* August 1947, by a patented process. A plaster of Paris pattern is made of the final die. The preceding dies are developed from this by working backward. A coating of tincture of green soap is applied to the plaster pattern, and a form, about ⅛ in. thick, is built with alternate layers of melted beeswax and cheesecloth. When cold and stiff, the built-up pattern is stripped off. It is then warmed until it becomes pliable and unfolded outward until it is reduced in depth by an amount considered feasible for one drop-hammer or press operation. When cooled and stiff, this beeswax-cheesecloth pattern is used for casting the plaster of Paris pattern for the next die. This is repeated for as many dies as necessary. The beeswax-cheesecloth pattern, although pliable, neither stretches nor shrinks, no matter how its contours are altered. The surface area of the pattern is not changed. The process is applicable to most complex and irregular shapes, but is not adaptable to shapes such as cylindrical cups.

Autoclave and other pressure vessel designs up to 3,000 psi are covered by an ASME code; above this pressure, the ASME and Lamé Formulas are applicable, but not the code. In a review of key factors in pressure vessel design, *Machine Design,* August 1947, C. A. Long indicates that safety factors must be reduced as the pressure goes up. This is necessary to keep head and wall thicknesses within practicable limits. With pressures of 25,000 psi, it may be necessary to reduce the safety factor to two. It has been found that only low tensile steels are suitable for fabricating welded pressure vessels. High tensile steels can be used in forming seamless forged vessels. These should be made from ingots or billets with a reduction of about three to one. For pressures over 40,000 psi the autofrettaging process is used to prepare forged vessels. Hydrostatic pressures of 40,000 to 100,000 psi are applied to the interior. The steel is stressed beyond its elastic limit and permanent growth occurs. The proportional limit and tensile strength of the steel are increased by this treatment. High-pressure bodies are sometimes made of cast carbon or stainless steels, or combinations of castings, forgings and plates. In the higher pressure ranges, castings are generally avoided because of possible casting defects. Hastelloy alloys are used for corrosion resistant bodies.

Stainless and special steel tubes can be formed by an extrusion process. This process, described by H. Lorant, *Mechanical Engineering,* June 1947, requires high quality wear- and heat-resistant tools, temperatures up to 2,400 F and fast-working presses. Tubes, 1½ to 2⅜ in. OD with walls 0.16 to 0.25 in., have been made from billets preheated to 2,300 degrees Fahrenheit. The method is particularly useful for special alloys that can be hot-worked only within a very narrow temperature range. It may be useful for steels that crack, because of destruction of the fiber structure, when worked in a piercing mill. The tubes have perfect internal surfaces and good structure. Round and hexagonal bars and simple profiles can also be produced by this technique.

Fig. 1—Typical use of supersonic waves is for locating flaws in materials such as ferrous disks for impeller wheels.

Supersonic Examination of Materials

BENSON CARLIN
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Outstanding characteristics of supersonic waves above 20,000 cycles and their use for detecting and locating flaws in metals, plastics, and other materials used in design.

SMALL discontinuities within most metals, plastics, other solids and liquids, can be detected and precisely located by supersonic test methods.

This non-destructive method of investigation sends pulses of supersonic vibration into the material under test and measures the elapsed time between the transmission of the pulse and the return of a reflection or the reception of the pulse at another point on the part. Because of their nature, supersonic waves are reflected or refracted at a boundary to a much greater degree than many other types of radiation. Therefore, when any flaw in the material has proportions that are comparable to the wave length a reflection will be received back from the discontinuity. A typical supersonic test, Fig. 1, is fast, accurate, and simple to make.

Significant Characteristics

A major advantage of supersonic testing is that the size of the flaw that can be located is not limited by the total amount of material penetrated. Thus a hole a few thousandths of an inch in diameter would be a very small percentage of a 15 in. block, yet it is detected as easily as in a 3 in. block. Moreover, supersonic energy is as powerfully reflected by a crack that has its surfaces closely pressed together as by one where there is a large separation. Such flaws are often found in materials of such great density that they are visible only after sectioning and etching. There is practically no lower limit on the size of flaw that can be located.

The highly directional characteristic of the supersonic beam makes it possible to investigate a particular assembly, even when there are other

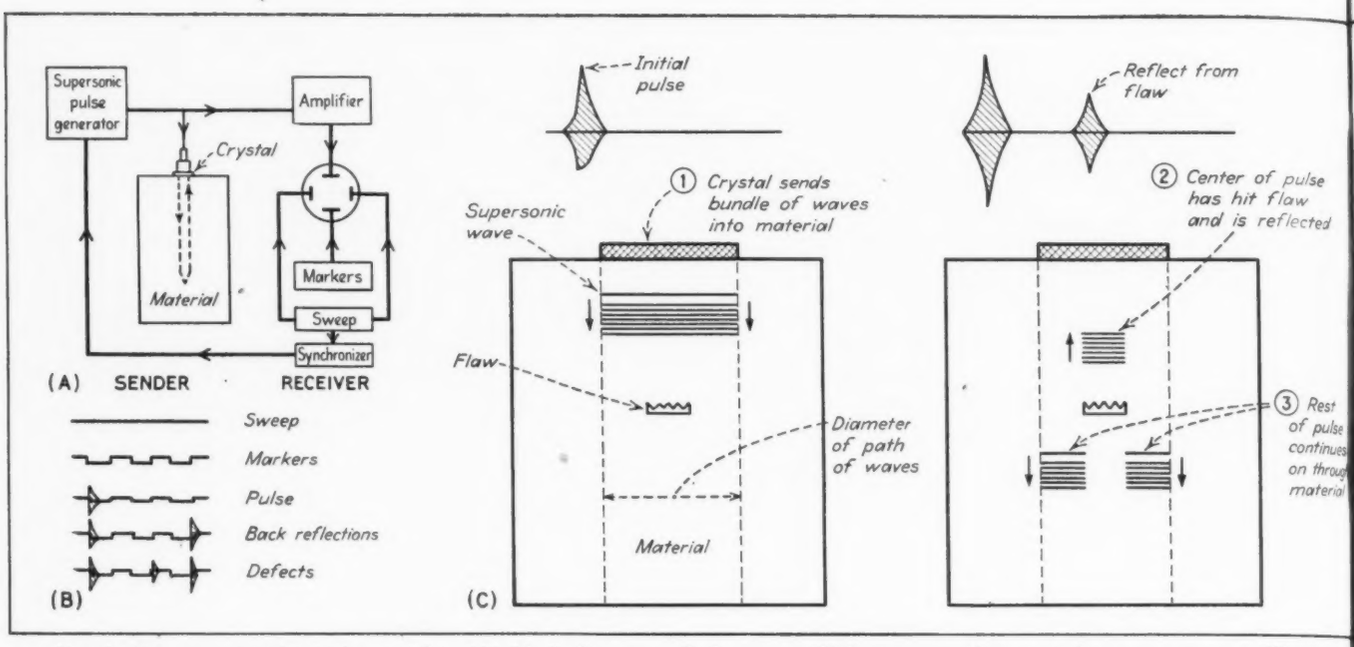


Fig. 2—How supersonic testing works. (A) Block diagram of elements. (B) Diagrammatic traces that appear on oscilloscope

parts surrounding it and when only a small section of the end surface is available for test. The waves easily penetrate great masses of metal, and can be used on large steel billets to determine cropping points, for example.

Flaws can be detected at distances from ½ in. to more than 10 ft from the face of the testing surface. The size of the flaw does not limit the distance at which it can be found; a No. 60 hole ⅛ in. long is located as easily at 10 ft as at ½ in. The amount of penetration does not depend on frequency except when the supersonic waves are scattered by discontinuities in the material. To have this effect such discontinuities must be of the order of magnitude of a fraction of the wave length.

The orientation of the flaw is important if it is a fine hairline crack with no appreciable thickness. If this crack is parallel to the face of the transducer it offers a maximum surface for reflection. The projection of a flaw upon a plane parallel to the face of the crystal probe is the surface that reflects the wave.

Supersonic testing is essentially instantaneous. Under ideal conditions it takes no longer to test a block 10 ft long than one 10 in. long. Since the time of travel of the supersonic energy is only a few micro-seconds, readings are instantaneous regardless of the length of the article under test.

Supersonic vibrational waves are defined as waves of a frequency above the usual range of hearing, that is, above 20,000 cycles. Various investigators have referred to the production of vibrations at a frequency as great as 5×10^8 cycles.

Utilizing Supersonic Waves

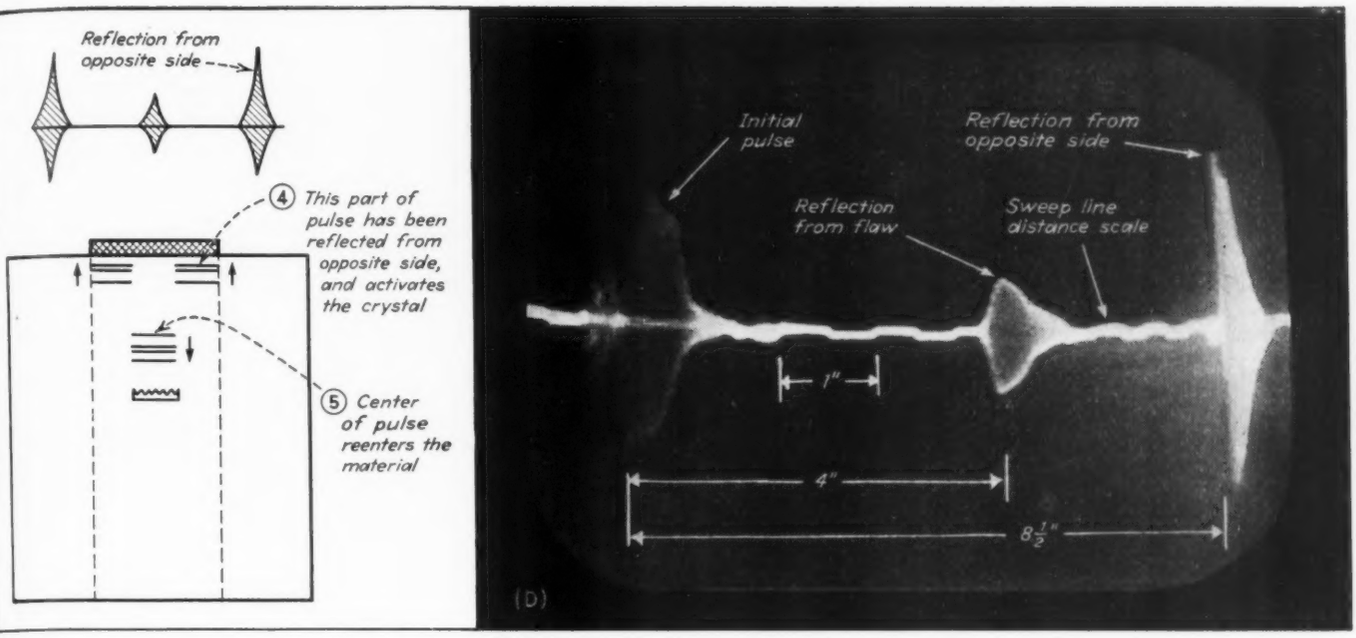
In solids the velocity is approximately 4,000 meters; therefore, a wave length from 20 to 8×10^{-4} centimeters is possible. In liquids, ranges from 6 to 2.4×10^{-4} cm have been reported. Since middle *C* on the piano has a wave length in area of approximately 1,300 cm the difference in wave length between audiole and supersonic sounds is clearly apparent. Where v = velocity, and f = frequency, and the wave length equals λ; then $\lambda = f/v$.

Since they are of very high frequency, supersonic waves travel in straight lines. This is referred to as rectalinear propagation. They are not appreciably refracted around small obstacles but are heavily reflected from any change in density or elasticity in their path.

The block diagram, Fig. 2, shows the essential components that comprise a transmitter and receiver. The transmitter consists of a pulse generator that produces a radio frequency pulse adjustable in length between 1 and 10 microseconds and of approximately 1,000 volts in amplitude. The supersonic energy from the pulse generator is radiated into the material by impressing it upon a suitable crystal transducer. Because of the Curie effect the transducer changes electrical energy into a mechanical vibration at a frequency determined by the crystal and the frequency of the pulse generator. As shown the transmitted waves travel as successive rarefactions and condensations in the material.

After each pulse is sent out the transmitter stops, the crystal quits oscillating and is ready to receive reflections from within the part on which it rests. If the supersonic waves passing through that part meet an obstacle they will be reflected strongly and some of the energy will return and again hit the face of the crystal. Thus the crystal is vibrated mechanically and because of the inverse piezo effect generates a small voltage that is received and amplified by the receiver. The superheterodyne amplifier has a band width great enough for resolution of about ¼ microsecond. This means that if two successive flaws in steel or aluminum are both indicated at the same time and vary $\frac{1}{32}$ in. apart, they will be seen as separate indications in their proper position. If they are less than $\frac{1}{32}$ in. apart they blend together.

The visual indicator is a cathode ray tube with a sweep that can be adjusted to best suit the size of the part being tested and the velocity of the supersonic waves travelling in it. Time intervals of the order of a


Reflection from opposite side
4 This part of pulse has been reflected from opposite side, and activates the crystal
5 Center of pulse reenters the material
3 Rest of pulse continues on through material
Initial pulse
Reflection from opposite side
Reflection from flaw
Sweep line distance scale
1"
4"
8½"
(D)

(C) Successive stages in detection of flaw tracing the sequence of wave travel. (D) Actual reflectoscope pattern showing flaw

microsecond, and therefore distance intervals of the order of ⅛ in., can be easily measured. The output of the amplifier is fed directly to this indicator and is synchronized so that the pulse sent out by the transmitter occurs at a convenient interval after the start of the sweep. Thus when there is no reflection the signal appears as in Fig. 2. When there is reflection a second indication appears, caused by the reflected energy. The distance between the transmitted and reflected pulses gives an exact measure of the time that the supersonic waves have been travelling through the part.

For simplicity in reading, a timing circuit superimposes a simple scale on the sweep. Each of these ruler-like marks can be set to indicate any distance from ½ in. to 2 ft. With a 1 in. scale setting in a particular material, the reflection from a defect 1 in. away will always fall upon the first of these marks and may be read directly from it. It is not necessary to know the velocity of supersonics in a material to calibrate these marks. The crystal is merely placed upon a part of known length and the proper number of scale marks set between the transmitted pulse and a reflection occuring at a known distance.

Any portion of the indicating sweep can be shown on the screen and expanded so that it takes up the entire area for closer examination of some particular part of the entire pattern. Also a pulse and all reflections may be moved back and forth on the sweep so that they fall at any convenient spot.

Velocity and Acoustic Impedance

Different types of supersonic waves can be generated, but the longitudinal wave is used most often. In this form of wave motion the particles move in a line parallel with a line of propagation of the supersonic energy. Supersonic testing usually uses longitudinal waves because: (1) the velocities are convenient without being too high for easy measurement; (2) they can be generated easily with x-cut crystals; and (3) this form of crystal can be coupled to the work by a thin oil film instead of having to be permanently fastened or otherwise attached. Where E = Young's Modulus, μ = Poissons Ratio, and d = density, the velocity V of a longitudinal wave is

$$V = \sqrt{\frac{E}{d}\,\frac{1-\mu}{(1+\mu)(1-2\mu)}}$$

The product of the density in gr per cu cm times the velocity of the transmitted wave in cm per sec, is the specific acoustic impedance of a material. This property is shown for several materials in Table I. This $d\,V$ characteristic is extremely important in supersonics because it indicates the amount of reflection and

Table I—Supersonic Properties of Common Materials

Material	Velocity, cm/sec × 10^{-5}	Density, gms/cu cm	Specific Acoustic Impedance × 10^{6}
Air	0.331	0 00120	0 0000413
Alcohol	1.44	0 79	.....
Aluminum	6 22	2 65	1 70
Bakelite	2.59	1.4	0.363
Brass	4.43	8.5	3 61
Copper	4 62	8.93	4 11
Glass	4.9-5.9	2.5-5.9	1.805
Lead	2.13	11 4	2 73
Magnesium	2 33	1 74	0.926
Mercury	1 46	73 6	1 93
Nickel	5.6	8.9	4 98
Polystyrene	2.67	1.1	0 294
Quartz	5.75	2.65	1 52
Steel	5.81	7 8	4.76
Transformer oil	1.39	0 92	0 128
Water	1.43	1.00	0.143

transmission between two materials at their interface. Using the specific acoustic impedance with the subscript 1 for one material and the subscript 2 for a second material, the ratio R of the amplitude of reflected to incident energy at a normal angle is

$$R = \left[\frac{d_1V_1 - d_2V_2}{d_1V_1 + d_2V_2}\right]^2$$

This relationship is shown for several materials in Table II.

Values in Table II represent the conditions existing with the two materials perfectly joined at the interface. In testing alloys where some of the alloying agents may have segregated out the percentage reflections are accurate; but when considering pressed fits or adjacent parts that appear to be well mated, there always exists a sufficient film of air, oil, or other foreign matter to increase considerably the percentage of reflection at the interface.

When most metals are bonded together their acoustic impedances are so alike that there is no appreciable reflection. The amount of reflection from a metal to air interface is approximately 100 percent, regardless of the amount of separation. Because of this, a reflection is caused primarily by the fact that there is an interface and depends only slightly on the thickness of the defect.

Supersonic investigations can be conducted using two crystals so that they send energy into a part at one point and receive it at some other point. The usual method is to use one crystal and observe the damping of the signal. The amount of transmission is of value in testing whether or not a given part will absorb large amounts of the supersonic energy. If the amount of absorption is predetermined for a standard part, it is often possible to detect defective material by the increased absorption of energy.

Crystal transducers for operation at four standard frequencies are ordinarily used. These quartz crystals are x-cut and have a thickness equal to one-half of their wave length. They therefore resonate at the test frequency. Usable frequencies range from 0.25 to 12 megacycles, but ½, 1, 2¼ and 5 mc are commonly used. These frequencies serve most of the common needs for testing in metals, although transducers for other frequencies can be made. Frequencies higher than 12 mc are rarely used since the x-cut crystals are too thin for practical use at such frequencies. Tests show little functional advantage over results at lower frequencies.

The wave lengths at the standard frequencies for some of the common materials are shown in Table III. The amount of reflected energy depends not only upon the basic considerations already described, but also upon the relation between the size of the reflecting surface of the flaw and the wave length at the frequency used. Thus Table III is an indication of the frequency that can be used in testing a material. For depth of penetration in metallic and non-metallic material see Reference Book Sheet, page 169.

A single crystal transducer usually is used as both sender and receiver. The crystal is plated for greater mechanical strength and for convenient electrical contact. The material under test is one electrode and is maintained at ground potential. The high voltage radio frequency is applied to the back of the crystal so that it cannot be touched by the person using the instrument.

The usual crystal for use at 5 and 2¼ mc is either ½ or 1 in. square, at 1 mc it is usually 1 in. square, for ½ mc the crystal is 2 in. square. These crystals may be made rectangular or of any other shape to fit on a particular part. The crystal is rarely made smaller than ½ in. square because of the limitation on the energy that can be transmitted into the part and also because the amount of beam dispersion is a function of the ratio between the face of the crystal and the wave length of the supersonic waves at that frequency. For special work ¼ in. square crystals have been successfully used.

If the frequency is so high that the wave length is of the same order of size as the inclusion in the material, it is impossible to penetrate it. Changing to a lower frequency of longer wave length avoids interference.

The transmission of energy into the material is highly directional. The beam does not spread appreciably, even when transmitted through many feet of material. The dispersion of the beam can be calculated from the ratio of the diameter of the front face of the transducer and the wave length. Where $\lambda =$

Table II—Perfect Reflection of Supersonic Vibrations Normally Incident To the Boundaries Between Various Media Perfectly Joined at Interface

Material or Medium	Specific Acoustic Impedance × 10^6	Aluminum	Steel	Nickel	Magnesium	Copper	Brass	Lead	Mercury	Glass	Polystyrene	Bakelite	Water	Oil	Air
Aluminum	1.70	0	21	24	9	18	14	3	1	2	50	42	72	74	100
Steel	4.76		0	0.2	43	0.3	1	9	16	31	77	76	88	89	100
Nickel	4.98			0	47	0.8	2	12	19	34	79	75	89	90	100
Magnesium	0.926				0	40	36	20	12	2	27	19	54	58	100
Copper	4.11					0	0.2	7	13	19	75	71	87	88	100
Brass	3.61						0	5	10	23	73	68	86	87	100
Lead	2.73							0	1	9	62	55	79	80	100
Mercury	1.93								0	4	8	6	75	76	100
Glass	1.805									0	40	32	65	67	100
Polystyrene	0.294										0	1	12	17	100
Bakelite	0.363											0	18	23	100
Water	0.143												0	0.4	100
Oil (transformer)	0.128													0	100
Air	0.0000413														0

Table III—Wavelengths in Common Materials in Inches

Material	Frequency, megacycles			
	1/2	1	2 1/4	5
Air	0.0688	0.0344	0.0153	0.00688
Aluminum	1.244	0.622	0.277	0.124
Bakelite	0.518	0.259	0.115	0.0518
Brass	0.886	0.443	0.196	0.0886
Copper	0.924	0.462	0.206	0.0824
Glass	1.040	0.520	0.231	0.104
Lead	0.426	0.213	0.0947	0.0426
Magnesium	0.533	0.237	0.107	0.047
Mercury	0.284	0.142	0.0632	0.0284
Polystyrene	0.534	0.267	0.119	0.0534
Quartz	1.150	0.575	0.255	0.115
Steel	0.581	0.259	0.124	0.052
Transformer oil	0.278	0.139	0.0618	0.0278
Water	0.290	0.145	0.0645	0.0290

Table IV—Surface Standards for Ordinary Reflectoscopic Testing

	General Electric		Surf-Check and Others	
	Roughness, microinches			
Symbol	Arithmetical aver. deviation from the mean	Average distance peak to valley	Roughness, root mean square microinches	Acceptance for reflectoscope testing
F4	63	220	60 to 80	Preferred finish for detecting defects as small as 0.005 in.
F5	125	455	100 to 150	Satisfactory for average testing for defects
F6	250	875	250 and up	Can be tolerated but not entirely satisfactory as this finish may reduce sensitivity because of poor surface contact

wave length, r = radius of transducer face, the ratio $\theta = 0.61 \sin^{-1}(\lambda/r)$. At most frequencies this ratio is so high that spreading is not a problem.

A second factor that influences the sharpness of the beam is the amount of random scattering within the material when the supersonic waves strike a large number of small inclusions or porosities. To a degree, the beam is then broken up and reflected haphazardly. This characteristic assists in the detection of such porous conditions.

Attenuation of the energy depends not only on the actual beam dispersion, but also on the viscosity of the material. Almost any metal, and especially those that are reasonably homogeneous and of close grain structure, can be tested by supersonic waves. Many of the denser plastics, and other materials of lower density, can be tested.

Supersonic testing can be used on any part where the crystal can be placed on a surface that is at least ¼ in. wide. If the part is very small with many offsets and holes, the results are difficult to interpret. The method is especially useful for investigating parts of large size.

Coupling Factors

If a crystal is placed upon the surface of a dry part, very little energy will be transmitted through the interface into the material because of the great difference in specific acoustic impedances at the interface. A suitable coupling acts like a transformer to match the impedance of the crystal to that of the work and is usually a liquid with a specific acoustic impedance between that of the quartz and that of steel. The particular couplant is not critical and transformer oil, automotive oil (SAE 20), mineral oil, water, benzine, Prestone, glycerine, chlorine, sugar solution, soap suds, mercury and various amalgams have all been used. For simplicity and economy, a thin transformer oil is excellent.

For best results, the oil must wet the part. The supersonic energy will then pass from the crystal, through the oil and into the part with comparatively little reflection at the interface. When the surface is very rough, thicker oils or any highly viscous liquid are usually better couplants for transmitting the energy into the material.

The surface of the material under test should be as smooth as possible. Where the surface is very irregular, as a result of such factors as pitting, rusting, or paint, the crystal is kept away from the work. To assure good contact for the transducer, rough surfaces should be smoothed by a hand grinder; most sand cast surfaces should be ground or sanded. Machined surfaces are satisfactory within the limits of roughness shown in Table IV. Most rolled or forged surfaces do not require extensive grinding, but should be cleaned with a portable sander. Scale that is firmly attached may be left on the material. Often the surface underneath such scale is wavy, so the most desirable surface for routine tests is a ground surface with a tight scale adhering to the entire surface.

Where the surface is curved and where the curvature is of a regular nature such as in a round pipe, the part can be tested with a flat crystal provided the convex surface has a radius of 9 in. or greater. Where the radius is small, curved crystals must be used. Where the surface is concave with a diameter of at least 24 in., usually flat crystals can be used. If the finish is extremely smooth, such as G.E. F-3 or better, standard flat crystals can be used on convex surfaces with a minimum diameter of 4 in. When required, curved crystals can be matched to any curvature.

Resonance and Absorption Methods

Besides using reflected waves, two other methods of supersonic testing can be used. They are:

RESONANCE. This method is used mainly for measuring thickness of a part where only one surface is available, as in a bonded material. The

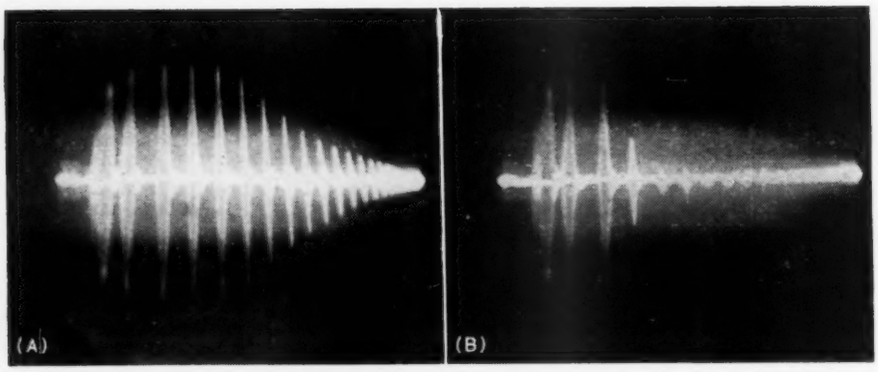


Fig. 3—Absorption wave diagrams showing: (A) Good material that has minimum absorption. (B) Typical defective material that has appreciable absorption.

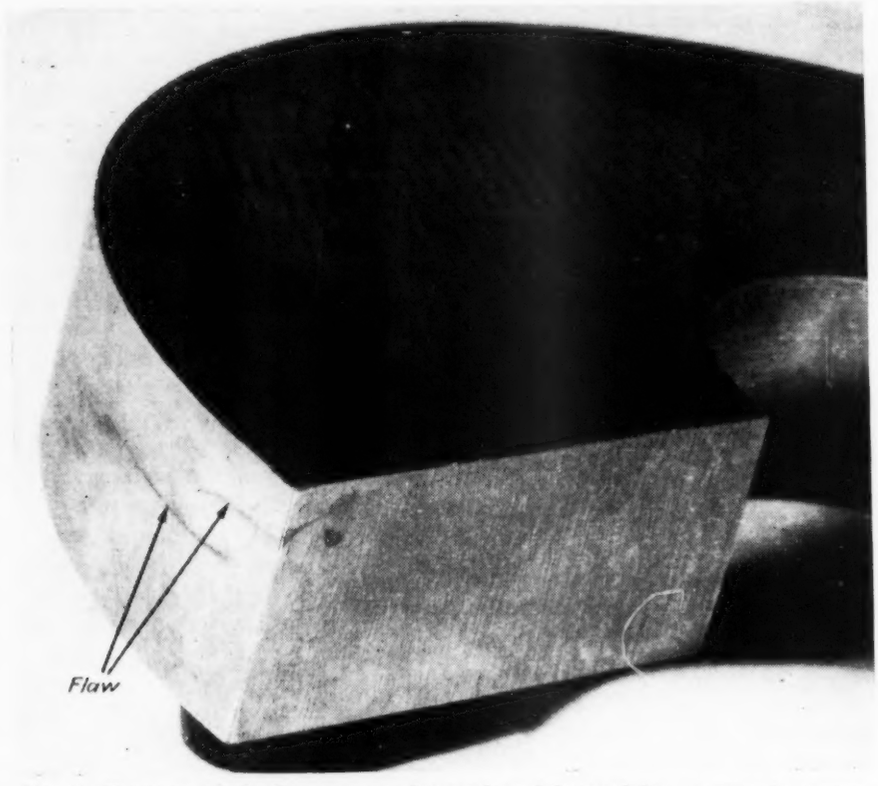


Fig. 4—These crankpin flaws were detected and located by supersonic waves.

frequency of test is varied until the thickness of the part is an integral multiple of the wave length. At that condition the material is resonant and less power is required to cause it to vibrate. Therefore the reflected signals are much larger. This method cannot be used satisfactorily on badly corroded parts such as pressure vessels or pipe lines.

ABSORPTION. The amplitude and number of the reflected signals indicate the amount of sound absorption by the material, as shown by the typical pattern in Fig. 3. On plate that is firm and sound, reflections of considerable height and number will be noted, while in badly laminated plate the reflections practically disappear. Such patterns are correlated to indicate differences in grain structure or internal condition.

Some Industrial Uses

In addition to research and development investigations, uses of the supersonic method include examining raw materials, testing semi-finished parts, detecting fatigue cracks caused by assembly methods or service conditions, and examining an intricate mechanism after it is built.

To prevent machining of a part with a flaw, supersonic waves are used for testing billets and other masses of steel, aluminum, magnesium and other metals. Steel plate can be tested for sulfide laminations or inclusions, for example.

A related application is the testing of semi-finished parts before final machining such as impeller wheels, drive shafts and turbine blanks before cutting teeth in the rotor. It is not necessary to retest a semi-finished part after it is completely finished.

Long aluminum spar sections can be tested from one end with one application of the crystal. When the spar is perfect only the pulse and the opposite side reflections appear. Similarly, supersonics is used for examining propeller blanks to insure that internal reinforcements are fastened and oriented properly; for testing of bond between the silver coating on a bearing and the steel of the bearing, or the bond of the cooling jacket in internal combustion engines, and for other applications. Generally, the chief limitation in supersonic testing for such devices is shape and size.

The supersonic method is excellent for fatigue testing. A big field is in periodic checks of materials that are under strain as they work. For example, locomotive axles and crank pins are tested without dismantling them in any way, with results as shown in Fig. 4. Other supersonic tests fatigue failure include those made on stern frames of large ships, back-up rolls used in steel mills, and shafts in large machines such as compressors and generators.

Future Outlook

Because the supersonic test method is relatively new, problems often arise where there is no prior experience. But progress is continuing rapidly and even in those applications that are impractical today, there is an excellent possibility that they will be practical in the near future. For example, there is some present difficulty in investigating materials that are heavily corroded or that contain many small inclusions. The field of corrosion is a large one and excellent progress is being made in solving it. Thus, as more engineers understand and use supersonic testing methods, their experience will both help solve difficult problems as they are suggested and also greatly expand the general usefulness of supersonics in industry.

External Floating Friction Shoes

Theoretical Analysis and Design

A. C. RASMUSSEN
Consulting Engineer

Derivation of formulas for computing the forces and reactions on any external floating friction shoe. Positioning the shoe to make the maximum intensity of pressure as small as possible is discussed. This article completes a series of five articles treating the analysis and design of friction shoes of all types.

A FLOATING SHOE of the external type, like the internal floating friction shoe, is held in place on the carrier or driving plate by a link that is pin connected to the shoe at one end and pivoted to the driving plate at the other, Fig. 1. The actuating force is applied to the shoe through a second link, which also is hinged to the shoe at one end and to an activating lever at the other end. Consequently the shoe is held against the drum by simple forces or thrusts acting through the two links.

These two forces together with the frictional force between the shoe and the drum have a single resultant. In designing a floating shoe mechanism, the shoe can be moved ahead or backward with respect to the two link connections so as to bring the center of the friction surface to the point where the single resultant force intersects the friction surface. The distribution of a load over a curved shoe was derived in a previous article on internal floating friction shoes. (See PRODUCT ENGINEERING, July, 1947, pp. 106-110) The distribution of the load over an external floating friction shoe is analyzed in the same manner.

When a load is off-center on the shoe, the maximum unit pressure is higher than the maximum unit pressure that occurs when the load is on-center. If the maximum pressure is reduced, the rate of wear at this point is reduced thereby causing a lower peak temperature. Thus softening of the binder in the friction lining, bleeding and fading are reduced. The definition of the symbols,

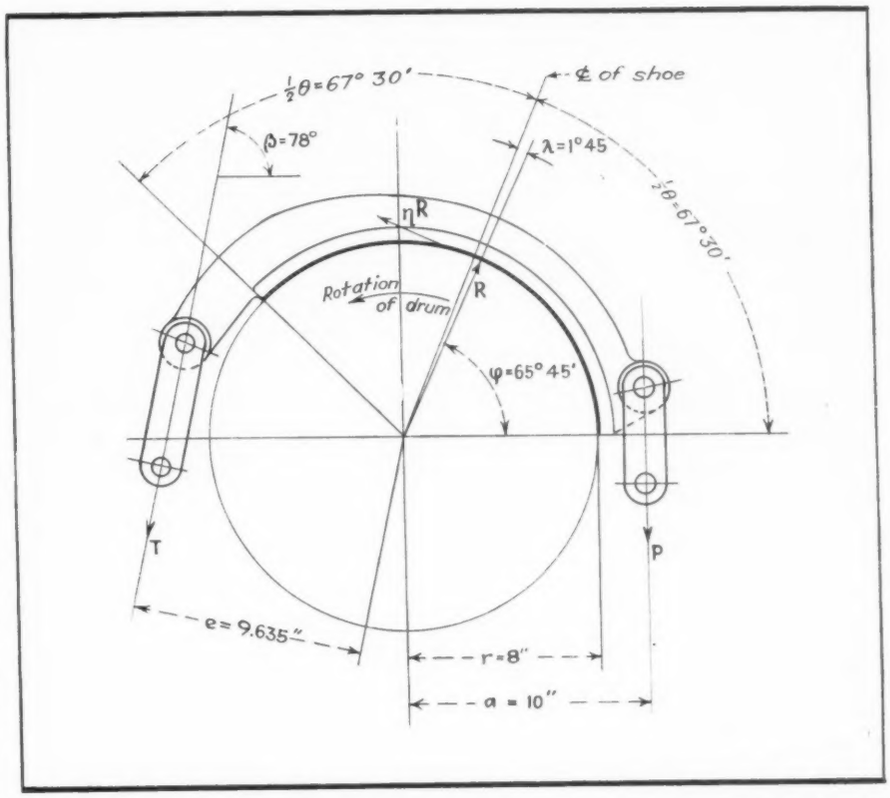


Fig. 1—External floating shoe to which the actuating force is applied through link *T* and the balancing reaction is carried to the driving plate through link *P*.

appearing in Fig. 1, are as follows. Let

T = Applied or activating force;
P = reaction at anchor end of shoe;
R = total force of shoe against drum;
μ = coefficient of friction of lining;
c = friction coefficient factor for a curved surface;
$\eta = \mu c$ = effective coefficient of friction of material on a curved surface;
θ = angular length of friction surface of shoe;
β = angle that T makes with x-axis;
ϕ = angle between R and x-axis;
e = radius of T;
a = radius of P;
E = ratio of self-energization.

Assume that the position of the resultant R is coincident with the center of the friction surface on the shoe. Should this condition not prevail, the position of the maximum pressure and the intensity of it can be determined by the methods previously presented in the analysis of the internal floating friction shoe. Whenever a new design of friction shoe is being studied, the friction surface should be moved forward or backward with respect to the hinge

pins until the center of the friction surface does lie along the line of action of the resultant R. Such centering of the force between the shoe and the drum, as already indicated, reduces the maximum unit pressure, which in turn means less temperature rise at this peak pressure point and less lining wear.

To simplify the force equations, the x-axis is placed on the force diagrams in such a way that the reaction P is always perpendicular to the x-axis; consequently reaction P has no horizontal component, Fig. 2. On the basis that the summation of the vertical components is zero,

$$P + T \sin \beta - R (\sin \phi + \eta \cos \phi) = 0 \quad (1)$$

If the function of ϕ comprising the quantity within the parentheses is denoted by k_ϕ, Eq (1) becomes

$$P + T \sin \beta - Rk_\phi = 0 \quad (2)$$

Likewise, from $\Sigma H = 0$,

$$T \cos \beta - Rh_\phi = 0 \quad (3)$$

in which h_ϕ denotes another function of ϕ (See Table 1).

Summation of moments about the center of rotation gives

$$Pa = Te + \eta Rr \quad (4)$$

The quantity P can be eliminated by combining Eqs (2) and (4) to get

$$T (a \sin \beta + e) = R (ak_\phi - \eta r) \quad (5)$$

If Eq (5) is divided by Eq (3) and the terms rearranged,

$$k_\phi - h_\phi \left(\frac{a \sin \beta + e}{a \cos \beta} \right) = \frac{\eta r}{a} \quad (6)$$

Let

$$m = (a \sin \beta + e)/a \cos \beta \quad (7)$$

and

$$s = \eta r/a \quad (8)$$

When these values, along with the trigonometric equivalents of h_ϕ and k_ϕ, are put into Eq (6), the following function of ϕ is obtained:

$$(1 + mn) \sin \phi - (m - n) \cos \phi = s \quad (9)$$

Either sin ϕ or cos ϕ can be expressed in terms of the other and the resulting quadratic equation solved for ϕ. With ϕ known, R and P can be computed from Eqs (3) and (2), respectively. Eq (4) can be used as a check.

When β is 90 deg, Eq (6) is indeterminate but the following analysis applies:

From $\Sigma H = 0$

$$R \cos \phi - \eta R \sin \phi = 0 \quad (10)$$

which gives

$$\tan \phi = \eta \quad (11)$$

and R and P can be computed from Eqs (3) and (2) as before.

The ratio of self-energization is found by comparing the moment of T_o required to produce a given value of R_o, with no motion, to the moment of T required to produce a value of R equal to R_o, but with motion. For moments about point L, Fig. 3

$$T_o (a \sin \beta + e) = R_o a \sin \phi_o \quad (12)$$

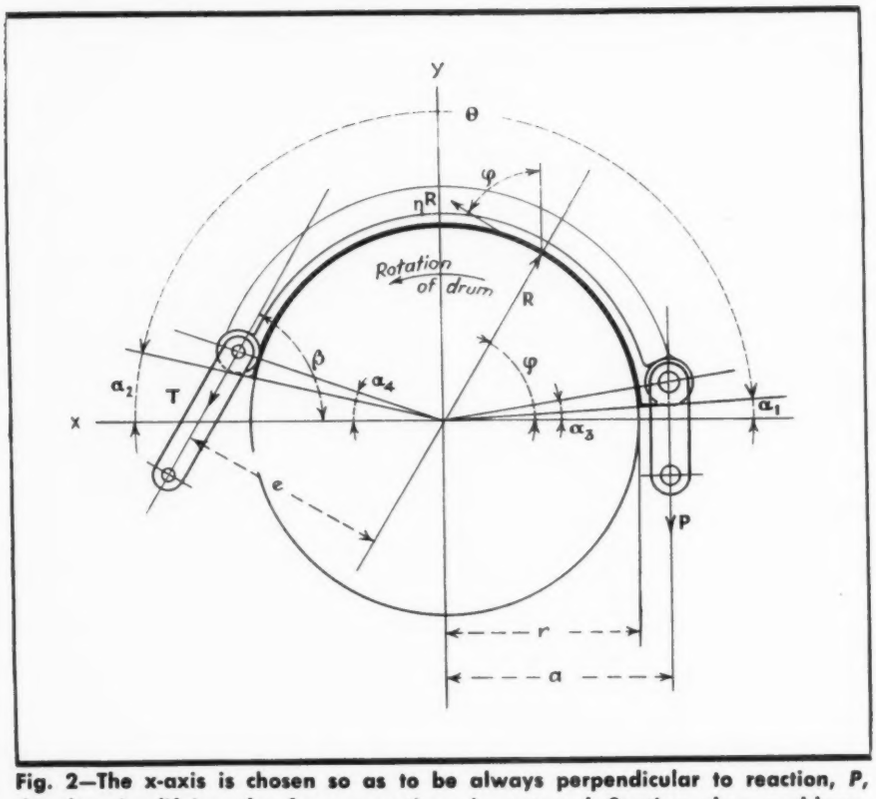


Fig. 2—The x-axis is chosen so as to be always perpendicular to reaction, P, thereby simplifying the force equations in external floating shoe problems.

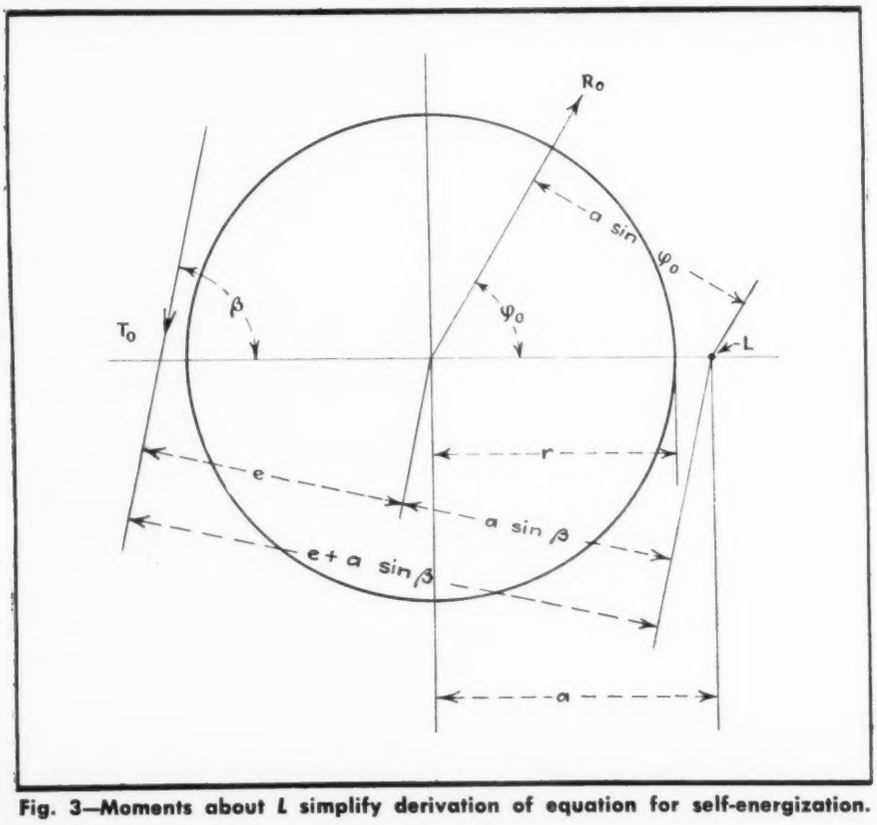


Fig. 3—Moments about L simplify derivation of equation for self-energization.

Since E is T_o/T, the self-energization by Eqs (12) and (5) is

$$E = \frac{R_o\, a \sin \phi_o}{R\,(a\, k_\phi - \eta r)} \qquad (13)$$

which for the condition that R_o and R are equal gives

$$E = \frac{\sin \phi_o}{k_\phi - \eta r/a} \qquad (14)$$

The value of ϕ_o is found from Eq (7) rewritten as

$$\tan \phi_o = \tan \beta + e \sec \beta / a \qquad (15)$$

When $\eta r/a$ equals k_ϕ, the denominator of Eq (14) is zero and locking occurs. To avoid locking therefore the ratio η/k_ϕ must be less than the a/r ratio.

With motion in a clockwise direction, or opposite that shown in Fig. 2, the direction of the frictional force, ηR, will be reversed. The force equations corresponding to Eqs (2), (3) and (4) are respectively

$$P + T \sin \beta - R i_\phi = 0 \qquad (16)$$

$$T \cos \beta - R g_\phi = 0 \qquad (17)$$

$$Pa = Te - \eta R r \qquad (18)$$

When β is 90 deg, summation of the horizontal forces yields

$$\tan \phi = -\eta \qquad (19)$$

If Eqs (16) to (19), inclusive, are applied in the manner outlined for the initial direction of rotation, the forces resulting from the opposite direction of rotation are readily computed.

Determination of the self-energization gives

$$E = \frac{T_o}{T} = \frac{\sin \phi}{i_\phi + \eta r/a} \qquad (20)$$

for which the value of ϕ_o can be found from Eq (15). Since the denominator of Eq (20) cannot become zero or negative, it is apparent that the shoe cannot be self-locking with reverse rotation of the driver.

Table I—Numerical Values of Trigonometric Functions

g_ϕ, h_ϕ, i_ϕ and k_ϕ for an η of 0.30.

$g_\phi = \cos \phi + \eta \sin \phi$ $\qquad$ $i_\phi = \sin \phi - \eta \cos \phi$

$h_\phi = \cos \phi - \eta \sin \phi$ $\qquad$ $k_\phi = \sin \phi + \eta \cos \phi$

Angle deg. ϕ	$\sin \phi$	$\cos \phi$	g_ϕ	h_ϕ	i_ϕ	k_ϕ
0	0.00000	1.00000	1.00000	1.00000	−0.30000	0.30000
5	0.08715	0.99619	1.02234	0.97005	−0.21170	0.38601
10	0.17365	0.98481	1.03690	0.93271	−0.12179	0.46909
15	0.25882	0.96593	1.04357	0.88828	−0.03096	0.54860
20	0.34202	0.93969	1.04230	0.83709	0.06011	0.62393
25	0.42262	0.90631	1.03309	0.77952	0.15073	0.69451
30	0.50000	0.86603	1.01603	0.71603	0.24109	0.75981
35	0.57358	0.81915	0.99122	0.64708	0.32783	0.81932
40	0.64279	0.76604	0.95888	0.57321	0.41297	0.87260
45	0.70711	0.70711	0.91924	0.49497	0.49497	0.91924
50	0.76604	0.64279	0.87260	0.41297	0.57321	0.95888
55	0.81915	0.57358	0.81932	0.32783	0.64708	0.99122
60	0.86603	0.50000	0.75981	0.24019	0.71603	1.01603
65	0.90631	0.42262	0.69451	0.15073	0.77952	1.03309
70	0.93969	0.34202	0.62393	0.06011	0.83709	1.04230
75	0.96593	0.25882	0.54860	−0.03096	0.88828	1.04357
80	0.98481	0.17365	0.46909	−0.12179	0.93271	1.03690
85	0.99619	0.08715	0.38601	−0.21170	0.97005	1.02234
90	1.00000	0.00000	0.30000	−0.30000	1.00000	1.00000
95	0.99619	−0.08715	0.21170	−0.38601	1.02234	0.97005
100	0.98481	−0.17365	0.12179	−0.46909	1.03690	0.93271
105	0.96593	−0.25882	0.03096	−0.54860	1.04357	0.88828
110	0.93969	−0.34202	−0.06011	−0.62393	1.04230	0.83709
115	0.90631	−0.42262	−0.15073	−0.69451	1.03309	0.77952
120	0.86603	−0.50000	−0.24019	−0.75981	1.01603	0.71603
125	0.81915	−0.57358	−0.32783	−0.81932	0.99122	0.64708
130	0.76604	−0.64279	−0.41297	−0.87260	0.95888	0.57321
135	0.70711	−0.70711	−0.49497	−0.91924	0.91924	0.49497
140	0.64279	−0.76604	−0.57321	−0.95888	0.87260	0.41297
145	0.57358	−0.81915	−0.64708	−0.99122	0.81932	0.32783
150	0.50000	−0.86603	−0.71603	−1.01603	0.75981	0.24109
155	0.42262	−0.90631	−0.77952	−1.03309	0.69451	0.15073
160	0.34202	−0.93969	−0.83709	−1.04230	0.62393	0.06011
165	0.25882	−0.96593	−0.88828	−1.04357	0.54860	−0.03096
170	0.17365	−0.98481	−0.93271	−1.03690	0.46909	−0.12179
175	0.08715	−0.99619	−0.97005	−1.02234	0.38601	−0.21170
180	0.00000	−1.00000	−1.00000	−1.00000	0.30000	−0.30000

Numerical values of the trigonometric functions g_ϕ, h_ϕ, i_ϕ and k_ϕ are given in Table I, in which the value of η is taken as 0.30. This value of η is low for the usual problem; nevertheless the tabular values are useful for comparisons. If the values must be used repeatedly in design calculations, graphs of these trigonometric functions are useful.

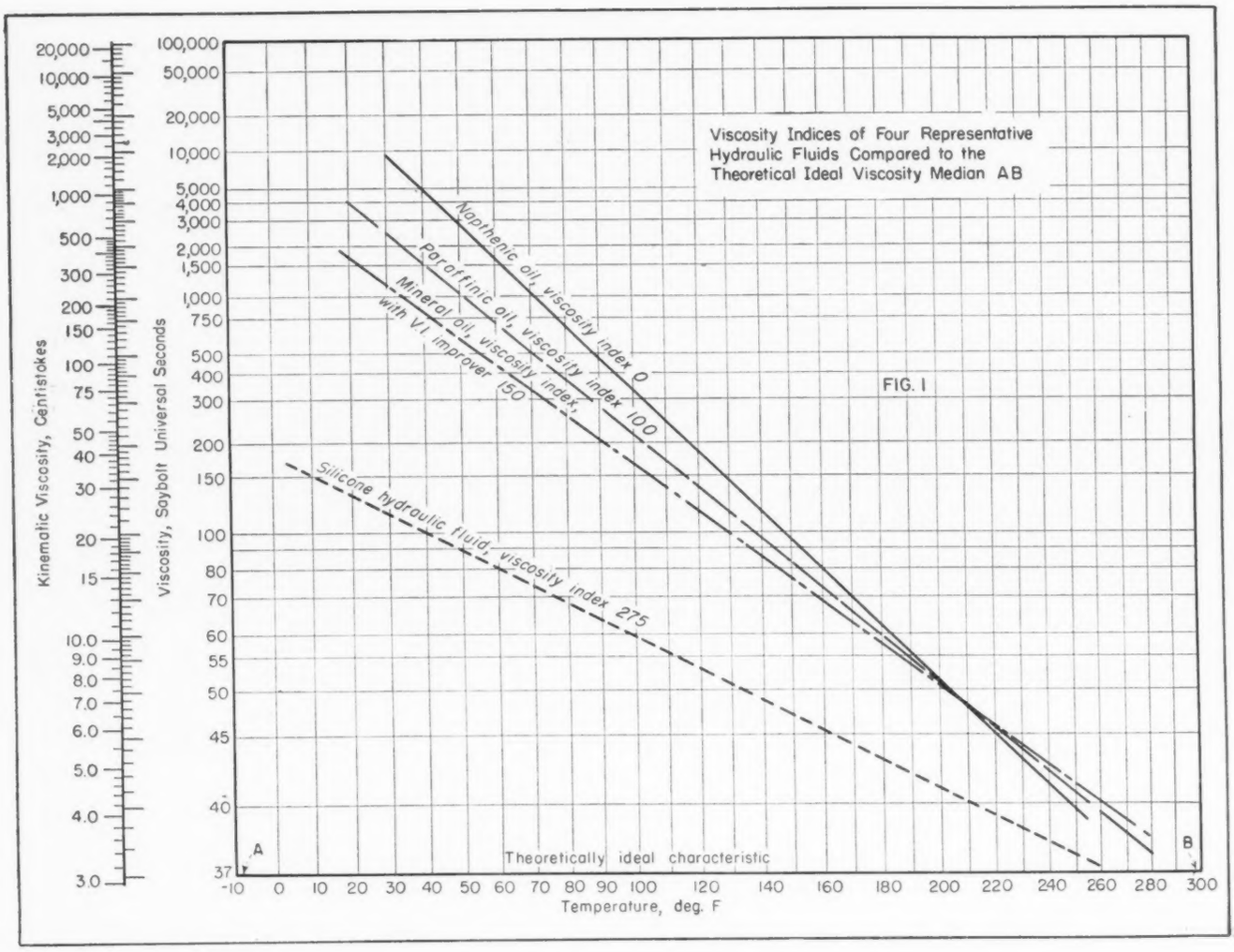
Reports on Tin-Free Solder to Replace Tin Solder

TIN-FREE SOLDER can be used as a replacement for tin-containing solder to a limited degree according to results of tests described in one of five reports of wartime solder research now on sale by the Office of Technical Services, Department of Commerce. The reports cover experiments and tests to find substitutes for tin solders.

Two other reports present the results of investigation of industrial uses of tin-free and low-tin solders made by the Battelle Memorial Institute, Columbus, Ohio under a War Production Board contract. One of the two is a brief survey of the various uses of tin-lead solders in the electrical industry.

The fourth report gives details of an investigation made to replace tin in solder with silver. The fifth report gives results of experiments made in studying the properties of modified lead-silver solder as a substitute for tin-lead solders used in the manufacture of small arms ammunition boxes.

Orders for the reports should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C.


Viscosity Indices of Four Representative Hydraulic Fluids Compared to the Theoretical Ideal Viscosity Median AB
Naphthenic oil, viscosity index 0
Paraffinic oil, viscosity index 100
Mineral oil, viscosity index 150 with V.I. improver
Silicone hydraulic fluid, viscosity index 275
Theoretically ideal characteristic
A
B
FIG. 1
Kinematic Viscosity, Centistokes
Viscosity, Saybolt Universal Seconds
Temperature, deg. F

Specifying Hydraulic Fluids

Seven primary characteristics to consider when selecting hydraulic fluids.

E. A. REEHL
Works Laboratory, General Electric Company

MANY industrial machines are depending increasingly on hydraulic fluids for proper operation. Machine tools, for example, often use hydraulics for obtaining smooth vibrationless action, rapid tool approach with slow cutting speed, and the cushioning effect on tools that usually improves the finish on the work piece.

For most applications on machines, straight mineral oil, or mineral oil plus additives, have replaced water as media for hydraulic power transmission. The body or viscosities of these materials ranges from 150 to 1,000 Saybolt Seconds Universal (S.S.U.) at 100 deg. F., depending upon operating pressures and duty to be performed. Because of growing demand for machine tools with hydraulic systems for transmission and control of power, some companies have found it helpful to add a hydraulic oil specification to their material specifications handbook. The sample specification shown in Table I includes requisites for a light oil of about 150 S.S.U. a medium-bodied oil of 300 S.S.U., and a heavy oil of about 1,000 S.S.U.

These three basic functions of a hydraulic medium were used for establishing the specifications: (1) To provide a medium for transmission of power, (2) to lubricate internal moving parts, and (3) to prevent corrosion of the working parts. Other influencing factors included the consideration that a satisfactory hydraulic oil should maintain a good seal between moving parts and have sufficient film strength or load-carrying capacity to prevent metal-to-metal pickup under heavy loads.

Basic characteristics for specifying satisfactory hydraulic lubricants include: (1) Viscosity, (2) viscosity index, (3) load-carrying capacity,

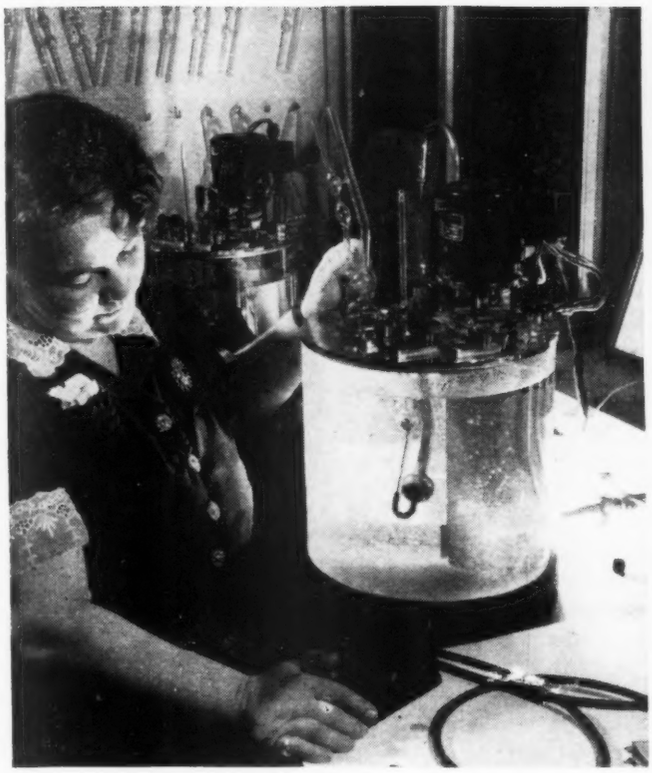


Fig. 2—Measuring viscosity by the precise kinematic method, using a modified Ostwald viscosimeter to obtain values.

Fig. 3—Measuring extreme pressure characteristics of lubricants; the higher the pressure the greater the load ability.

Table I—Specifications for Physical and Chemical Characteristics of Hydraulic Oils

Oil to be refined from petroleum oil, be free from water, sediment, acids and soaps. It should resist oxidation, have a viscosity index of at least 60, and have high demulsibility.

Type of Hydraulic Oil	Flash Point, Deg. F, min.	Fire Point, Deg. F, min.	Kinematic Viscosity Centistokes				Approximate Saybolt Universal Viscosity, sec.				Pour Point Deg. F. max.	Neut. No. mg. KOH/g, max.	Viscosity Index. min.	A.S.T.M. Steam Emulsion No., max.
			100 Deg. F.		210 Deg. F.		100 Deg. F.		210 Deg. F.					
			min.	max.	min.	max.	min.	max.	min.	max.				
Light.....	385	440	25	38	4	6	120	175	40	45	10	0.05	70	90
Medium.....	390	445	60	76	6.5	8	275	350	48	53	15	0.05	70	120
Heavy.....	450	500	173	205	16	18	800	950	80	90	45	0.10	70	.....

Test procedures to conform with A. S. T. M. methods as follows: Sampling, D-270; Flash and Fire Points, D-92; Viscosity (Kinematic), D-445; Viscosity (Saybolt), D-88; Pour Point, D-97; Neutralization Number, D-663; Viscosity Index, D-445; and Steam Emulsion, D-157.

(4) demulsibility, (5) acid number, (6) pour point, and (7) chemical or oxidation stability. The prime factor of oxidation stability is placed last, because its behavior is reflected by other factors, such as high acid number, low demulsibility (high steam emulsion number), increased viscosity, and formation of sludge and gummy deposits.

VISCOSITY. Viscosity of a liquid, in this instance a petroleum product, is a measure of its internal friction or resistance to flow. For years this property has been evaluated in terms of S. S. U. as an index. This method is based on determining the time in seconds required for 60 c.c. of oil at a specified temperature to flow through a certain size orifice. It has certain weaknesses, and errors occur under some conditions. A new and more accurate method for determining viscosity, called kinematic viscosity, is increasingly replacing Saybolt viscosity. This method uses suspended level capillary tubes and a constant-temperature liquid bath.

Both kinematic viscosity values and S.S.U. values are included in the General Electric specification for hydraulic oil. At some later date, it is likely that the older method of test will be dropped in favor of the more accurate kinematic viscosity.

Correct body or viscosity is one of the most essential characteristics of a hydraulic oil. There is always some degree of leakage or slippage in hydraulic pumps, which causes increased oil temperatures with consequent loss of efficiency for the system. Low-viscosity oils give assurance of quick flowing oils, but they

will promote excessive oil leakage and poor efficiency.

High-viscosity oils, on the other hand, give less leakage, offer higher resistance to flow, and ultimately result in higher power consumption. Hydraulic oils range in viscosities from a light oil of 150 S.S.U., to a heavy hydraulic oil of 1,000 S.S.U. at 100 deg. F viscosity index.

VISCOSITY INDEX. After years of discussion as to its need in a hydraulic specification, viscosity index is a characteristic that is now considered necessary for a well rounded standard for hydraulic oils. An oil having a high viscosity index, or V.I., is one that has a minimum change of viscosity over a given temperature range. As shown in Table I, a good hydraulic oil should possess a viscosity index of 70 or more.

Although wide temperature variations may not be encountered in the hydraulic systems during normal operation, high viscosity index oils often are still desirable. For example, after the week end shutdown of equipment a high-viscosity index oil insures efficient operation of hydraulic systems for the first few hours of the new work week. Generally the use of a hydraulic oil of 70 V.I., or less, causes higher power losses and lower overall existing efficiency.

The ideal hydraulic oil would have the same viscosity at all temperatures, but this is an improbability in the present field of petroleum products. While the perfect fluid with uniform body at all temperatures has not yet been realized, it now is being more nearly approached through use of synthetic silicone fluids. In addition, the high flash points and low pour characteristics of the silicones merit serious consideration when selecting a good hydraulic oil.

LOAD-CARRYING CAPACITY. In systems operating at 2,000 lb. per sq. in., or above, film strength or load-carrying capacity may become a factor in the selection of hydraulic oils. This may require the addition of certain materials in the hydraulic medium to increase the film strength and prevent metal-to-metal contact at higher pressures. Lack of this characteristic on a machine tool will cause table, piston, and slide chatter, which will reflect in poor machinability of the work piece. In the future, hydraulic-oil specifications will probably list a Falex wear test or Almen number as an indication of the high load-carrying capacity required. There are several machines available for the measuring of load-carrying-capacity and while correlation of test results between machines is not too good, the Almen Extreme Lubricant Tester and the Falex Lubricant Tester show fairly reproducible results.

The Falex machine employs two V-shaped hardened steel bearing surfaces that are pressed against a rotating steel pin until seizure occurs. Both the pin and the V-shaped bearing blocks are immersed in the oil. Torque and applied load are measured by the use of two gages. Wear may also be calculated by disengaging a feed arm and running at a given load.

The Almen machine, developed by General Motors Corporation, uses a ¼ in. diameter polished drill-rod journal or pin and a ½ in. ground split bushing made from cold drawn steel. A 0.007 in. clearance is provided between the pin and normal diameter of the split bushing. Pressure is applied thru a series of lever arms until seizure occurs. Load is calculated in lb. per sq. in over a projected area and torque in inch-pounds.

DEMULSIBILITY. There is a direct relation between demulsibility, or the rate at which an emulsion will "break" or separate, and emulsification, which is the rate at which an emulsion is formed.

Oils with low demulsibility rating retain water, moisture, and air more readily than those oils with high demulsibility rating. Water in the hydraulic system may be from leakage of cutting oils into the oil reservoir, or moisture may result from condensation of atmosphere moisture caused by air moving in and out of breather pipes. The effect of air in a system charged with an inferior grade of oil usually results in noisy operation, chattering, and poor control of the equipment in general.

The method most generally used to evaluate demulsibility is the A.S.T.M. Steam Emulsion test, the results of which are recorded as A.S.T.M. Steam Emulsion Number or (S.E.No.). The number indicates the seconds required for an oil to separate water when emulsified with steam under prescribed conditions.

LOW ACID NUMBER. The acid number, or neutralization number as it formerly was called, of a petroleum product is a measure of the presence and concentration of constituents having acid characteristics. The acid number is the weight in milligrams of the alkali (usually potassium hydroxide) required to neutralize one gram of the material. Oils having high acid number sludge or emulsify rapidly. Pitting and corrosion of the metals then follows.

POUR POINT. Pour point is the lowest temperature at which an oil will flow or can be poured under prescribed conditions. Pour point is important in hydraulic oils, particularly after week end shutdowns of operating equipment. Factory buildings are generally cold for the first few hours at the beginning of each work week. Starting equipment with oils of high pour point cause sluggish operation of machine tools.

CHEMICAL OR OXIDATION STABILITY. Perhaps the most important overall qualification for hydraulic oils is chemical stability. When hydraulic oils operate at above normal temperatures in the presence of metals, moisture and air, oxidation begins and organic acids are ultimately formed. Of these acids produced in the earlier stages of oil deterioration, the high molecular-weight acids tend to prevent corrosion of exposed metals. This is not true of the low molecular-weight acids that promote corrosion. After a certain concentration of these acids is reached the solution reacts with susceptible metals, such as copper and iron, at the surface and forms metallic soaps. These soaps are soluble in the hot oil and are consequently washed from the metal surfaces. This exposes new metal and these subsequent layers continue to form more metallic soaps. These soaps promote the formation of emulsions and sludges, or gummy resins.

Future Trends

Future trends in the hydraulic liquid field will probably be away from the use of highly refined straight mineral oils (turbine-oil type) to in-

creased use of the straight mineral oil with certain additives, such as oxidation inhibitors, corrosion inhibitors, pour point depressants, and viscosity index improvers that is beginning to find increasing favor. But eventually it seems certain that hydraulic oils will come from the new synthetics, such as the silicones.

These poly-organosiloxanes have several outstanding characteristics as discussed by Messrs. Fitzsimmons, Pickett, Militz and Zisman in A.S.M.E. Transactions, May 1946. They have exceptionally high chemical stability. In the absence of oxygen, certain of these materials are stable at temperatures above 200 deg. C., and in the presence of air remain free from acid formation, sludging and gum formation at 150 deg. C. The silicones approach the ideal petroleum oil in having extremely high viscosity indices. They have a low pour point, and have functioned successfully in machinery in a cold room at —60 deg. C. Furthermore, they are non-corrosive to metals. No corrosion whatever has been found when silicones, brought into contact with metals such as brass, bronze, aluminum, and steel, were subjected to 150 deg. C. in the presence of air for a long time.

The silicone-polymers are limited in their load-carrying capacity or "film strength" where both sliding surfaces are ferrous metals. But when one, or both, of the sliding surfaces are non-ferrous metals the load-carrying capacity is satisfactory. Concentrated efforts are being directed towards improving the lubricating qualities of these fluids, particularly when used with ferrous metal combinations, and additives will probably be found to improve this characteristic.

Water Channel Technique Simulates Supersonic Waves

A SIMPLE TECHNIQUE to simulate the supersonic shock wave system created by high speed airplanes and pilotless missiles—towing models through a water channel—has been adapted by engineers in North American Aviation's Aerophysics Laboratory

Application of the technique by North American Aviation marks the first time it has been used in this country to study supersonic speeds in aircraft and guided missiles.

Speeds up to 7,000 mph. can be simulated by towing models through a water channel only ¼ in. deep.

North American engineers tow models representing supersonic wings, ram jets or similar components through the channel by means of a wheeled stand. The stand holds both the model and a camera which records the shock wave patterns sent out by the models.

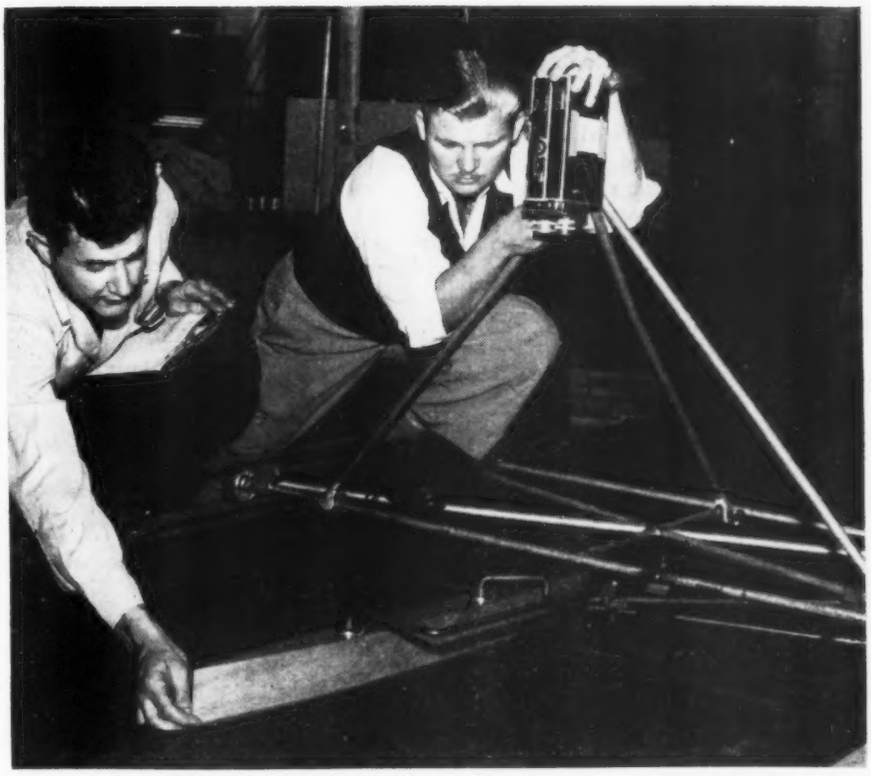
Water wave patterns created by models being towed through the shallow channel are similar in shape to the shock waves sent out by a body flying at supersonic speeds.

It is possible to simulate an airfoil at a speed of 3,000 miles an hour—four times the speed of sound in the air. The model is towed through the water channel at a velocity of 3.6 feet per second, which is four times the velocity of water waves in a channel one-quarter of an inch deep. The velocity of sound is thus replaced by the velocity of the water waves.

Dr. William Bollay, head of North American Aviation's Aerophysics Laboratory, points out that the water channel system is less expensive than supersonic wind tunnel tests, and also can be used to simulate accelerated motions. The disadvantage is that the resulting data are not as accurate as wind tunnel tests, but are useful for qualitative supersonic studies.

The technique of using the analogy of water waves and shock waves in the air was first proposed in this country by Theodore von Karman of the California Institute of Technology for the problem of studying the optimum design of water channels for the Los Angeles County Flood Control District.

North American Aviation's aerodynamiscists are now working in the opposite direction—going from the experimental water channel to deduce the supersonic flow of air.



Photographic records are made of shock wave patterns created by towing the model of a supersonic wing through water in North American Aviation's laboratory.

Electrical, Mechanical and Fluid

Various speed changing devices including an outline of their principles of operation and a description of some of the materials used in their construction. Uses and limitations of the eight units described, including planetary and changing diameter types, are discussed.

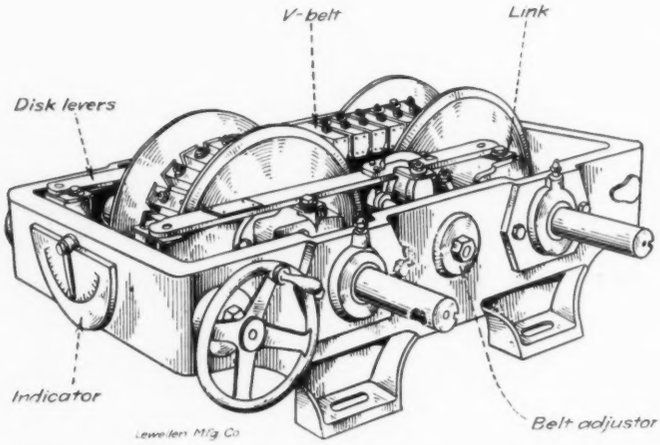


FIG. 1—The Lewellen Variable Speed Transmission has two parallel shafts mounted in a rigid frame. Either shaft can be used as the variable speed shaft and the transmission can be run in either direction. Two cone-faced disks are spline-mounted on each shaft and all four disks move laterally when changes of speed are desired. A double block V-type belt connects the two pairs of disks. The control wheel turns the screw that positions the disk levers. These levers are pivoted in such a way that each disk moves the same distance. The levers transmit their thrust loads through links at each end. The thrust load is equally distributed over the bearing surfaces because the links are pivoted about the centers of the bearings. Stop collars fitted on screw limit disk separation.

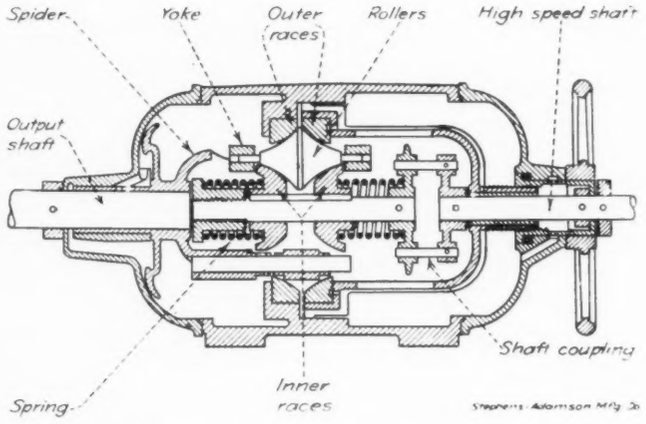


FIG. 2—Different operating radii on double cone-shaped rollers cause reduced variable speed output. Power of the JFS Variable Speed Reducer is passed by the high speed shaft to the full-floating center shaft via a compensating coupling. Two longitudinally moving inner races are secured to the center shaft by feather keys. These races engage the three rollers because of spring pressure. As the rollers revolve, they rotate as a planetary because of their outer race contact. The rollers are attached to a spider, rigidly keyed to the output shaft, through individual yokes. One of the outer races is fixed; the other is controlled by the handwheel to change the relative points of contact between the rollers and races. The inner races are positioned by the pressure of the rollers.

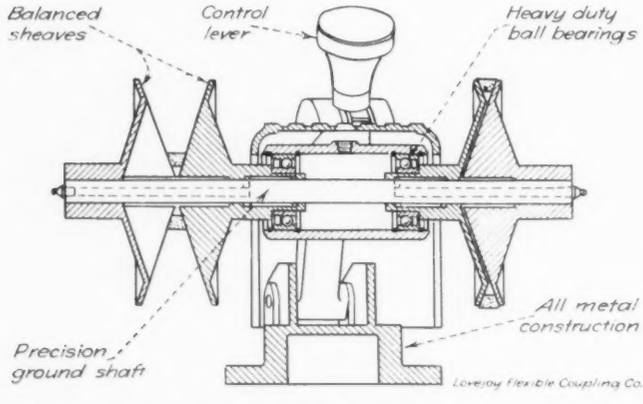


FIG. 3—Constructed of metal throughout and using standard V-belts, the Select-O-Speed has two variable pitch sheaves mounted on a pivoted shaft. The two inner halves of the sheaves are positively located in the housing assembly, and the outer halves, pinned to the floating splined shaft, are free to move laterally. As the control lever is shifted in its diagonal direction, the shaft assembly moves with it, keeping the belt centerlines fixed and aligned with the driving and driven units. The protective housing, fastened to the shifting links, moves with the control lever.

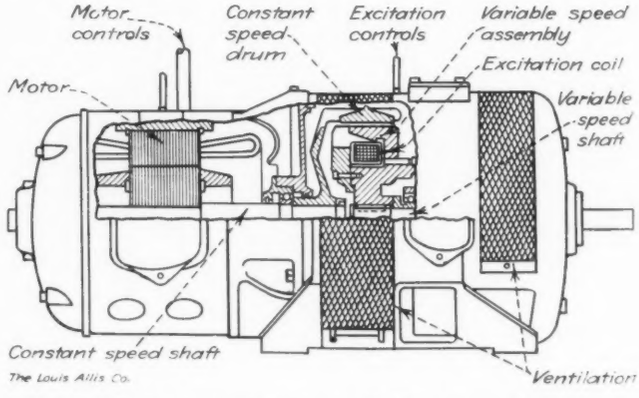


FIG. 4—Made to transmit controllable torque, the Adjusto-Spede uses electro-magnetic forces and no mechanical connection between the driving and driven members. A squirrel-cage induction motor and an eddy current clutch are combined in one unit. The clutch has special poles that concentrate flux at the pole ends, which develops constant torque between the driving and driven members. Variable delivery speed is determined by the amount of slip between the drums. Any required slip can be had by changing the clutch coil excitation. Shock loads are absorbed electrically and not mechanically.

Variable Speed Transmissions—I

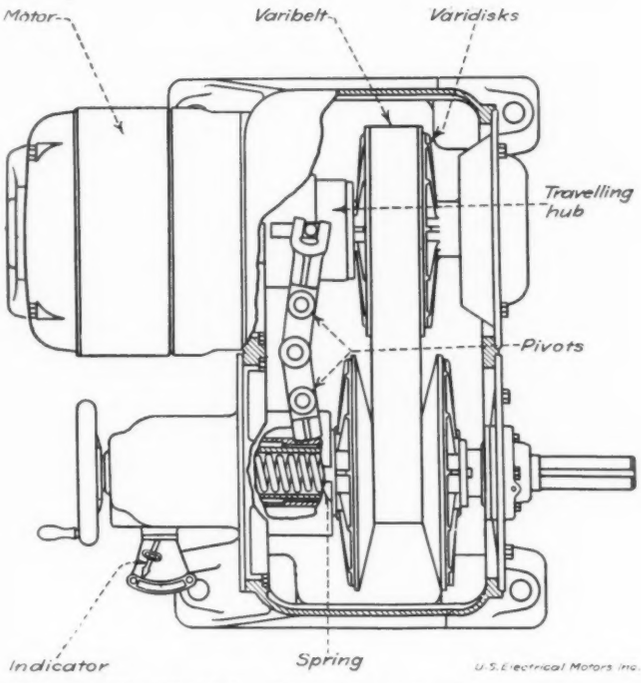


FIG. 5—The Varidrive Motor is made of a constant speed squirrel-cage motor and two pairs of Varibelt-connected Vari-discs. The speed is changed by varrying the effective driving diameters of the sheaves. A calibrated helical spring automatically keeps the pulley sections in proper contact with the belt. The threaded handwheel shaft actuates the traveling hubs, controlling the lateral movement of both sets of disks to reciprocally expand and contract the width of the pulleys.

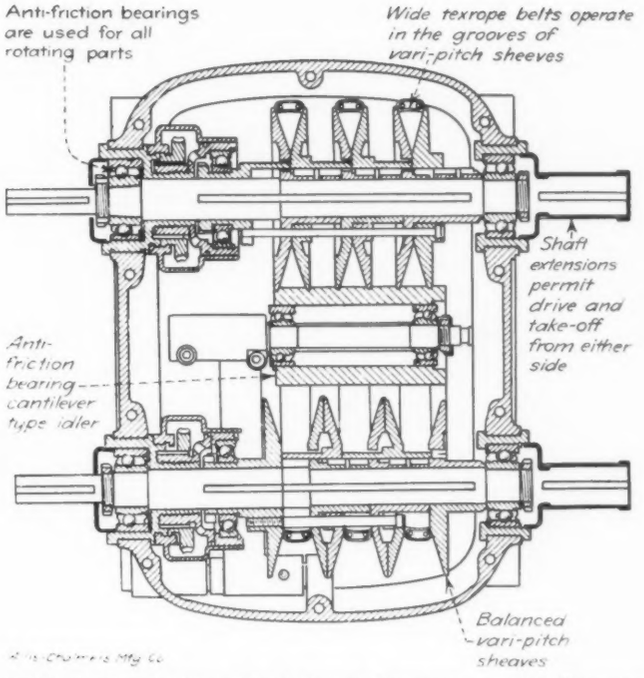

Anti-friction bearings are used for all rotating parts
Wide texrope belts operate in the grooves of vari-pitch sheeves
Shaft extensions permit drive and take-off from either side
Anti-friction bearing—cantilever type idler
Balanced vari-pitch sheaves

FIG. 6—In the Vari-Pitch Speed-Changers, special Texrope V-belts and Vari-Pitch sheaves have been combined to provide infinite variations of speed, and can be driven from either side of either end. The disks between which the belts operate are mechanically linked together, moving as a unit to effect the speed change. The disk positions and pitch diameters are maintained without the use of springs. The belt tension is held by a cantilever-type idler activated by gravity.

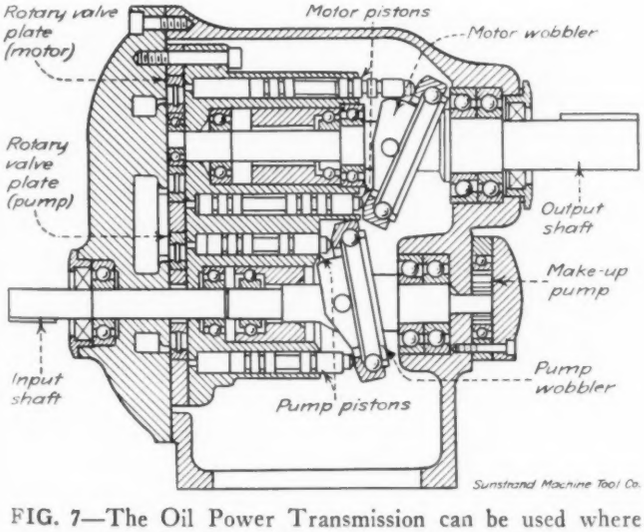


FIG. 7—The Oil Power Transmission can be used where right and left hand variable rotation and a neutral position are required. An electric motor drives a variable displacement multi-piston pump that delivers oil to a fluid motor of the same type. Oil is pumped from the reservoir to the cylinders by the make-up pump, mounted on the input shaft. This oil is delivered under sufficient pressure to hold the pistons against the wobbler plate on the return strokes of the pistons. Speed of rotation is dependent upon the angles of the wobbler plates; angles changed by the control mechanism.

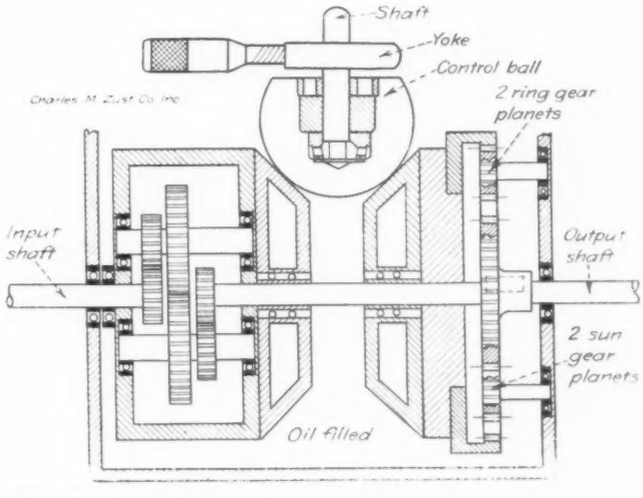


FIG. 8—A speed control that delivers constant torque at any fractional speed between that of the power source and zero, and between zero and 10 percent reverse, the Constantorque uses two planetary gear systems. A cylindrical differential carrier incloses a planetary unit of six gears always in mesh, and is free to rotate about the input and output shafts. This carrier has a 45 deg. angled face in contact with the freely rotating control ball. Another angled disk connects to the output shaft through a six gear planetary, and is in contact with the control ball. As the ball tips, the speed reduces.

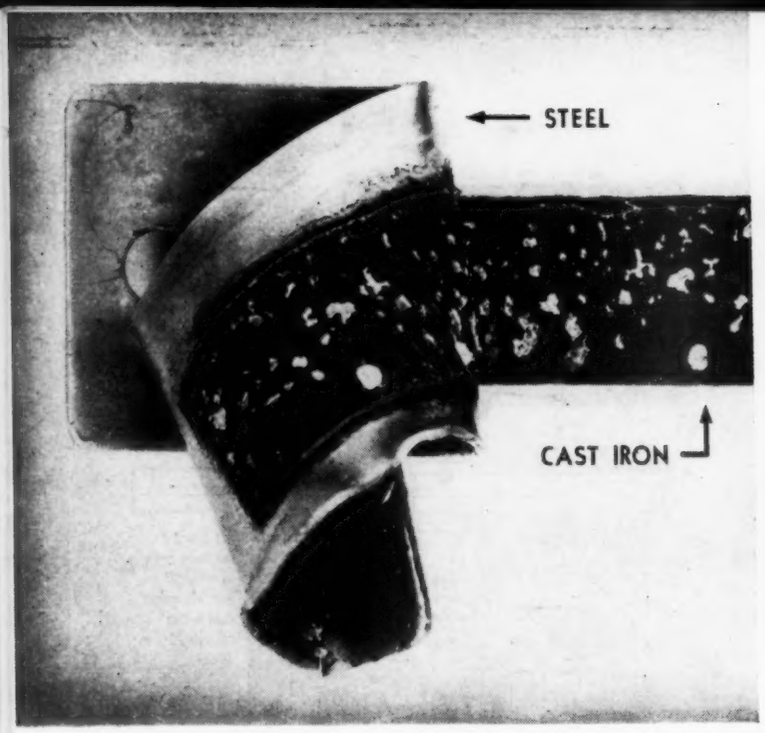


Fig. 1—A silver brazed cast iron and steel bond is stronger than the cast iron, providing a good bond exists. The rupture takes place in the iron because the tensile strength of AMS 4770 silver solder is 40,000 lb per sq in. or more.

Fig. 2—The photomicrograph above shows how a low surface tension metal makes a strong bond with prepared cast iron. The bonding metal flows into these microscopic cavities left by removal of the sand and graphite inclusions.

Design Possibilities in the Silver

RARELY is one material the best material for every part of a design and therefore castings always represent a series of compromises. Now there is a reliable and economical method of joining most metals to our basic casting material—grey iron. This method, sometimes incorrectly termed silver soldering, is silver brazing. It enables the designer to apply a wear-resistant material here, a high temperature alloy there, a corrosion proof material elsewhere. In short, the designer can use a cheap, simple casting but still have the right material at the right spot. It follows that grey iron castings then have a much wider field of application. Design possibilities using this type of construction have scarcely been considered.

The silver brazing of ordinary cast iron has heretofore been considered commercially impractical. Scale graphite and sand inclusions on the casting surface prevent a firm, uniform bond. To obtain a strong joint, it is necessary to remove all dirt, grease, and oxide from the surface, as well as graphitic inclusions, combined carbon and sand. There has been no good way of doing this surface preparation until a wartime development was put into widespread commercial use.

By a combined cleaning and surface preparation process, machined or unmachined cast iron surfaces can be fixed to accept silver brazing. The resultant bond, shown in Fig. 1, has as great strength as the parent metal.

Surface Preparation

The process is carried out by suspending the parts in an open container of catalyzed molten salts, through which an electrical current is passed. Surface impurities are removed by the formation of oxidation and reduction members as the direction of current flow is reversed.

The surfaces are then fluxed with AMS 3410 and silver brazed with AMS 4770 in the usual manner. Fig. 2 shows the type of bond resulting between steel, grey iron and silver brazing material. Because of its low surface tension, the alloy (tinning metal in this case but equally true of silver solder) has penetrated into the microscopic apertures from which sand and carbon were removed, thus forming a uniform and tenacious bond between the two materials.

Given a practical technique for silver brazing cast iron, what are the design possibilities?

Some proven advantages of using this process are as follows:

1. Dissimilar metals can be brazed to cast iron where desired. This results in a structure having the basic simplicity of an iron casting with the advantages of special properties at necessary points. Cast iron can be silver brazed to iron, steel, stainless steel, Monel, Inconel, Everdur, copper-nickel alloys, chrome-nickel alloys, brass, bronze and many other alloys.

2. Intricate forms can be built up from simple castings silver brazed to each other or to other metals. Also assemblies can be made of castings brazed to standard forms such as seamless tubing, angle iron and channels.

3. Simple castings can be machined easily before final assembly, then silver brazed together in fixtures so as to hold desired overall dimensions. If high-temperature brazing were used, the work might have to be machined after assembly because of heat distortion. Fixtures and machining would then be more complicated.

4. Foundry work can be simplified by making an intricate casting in

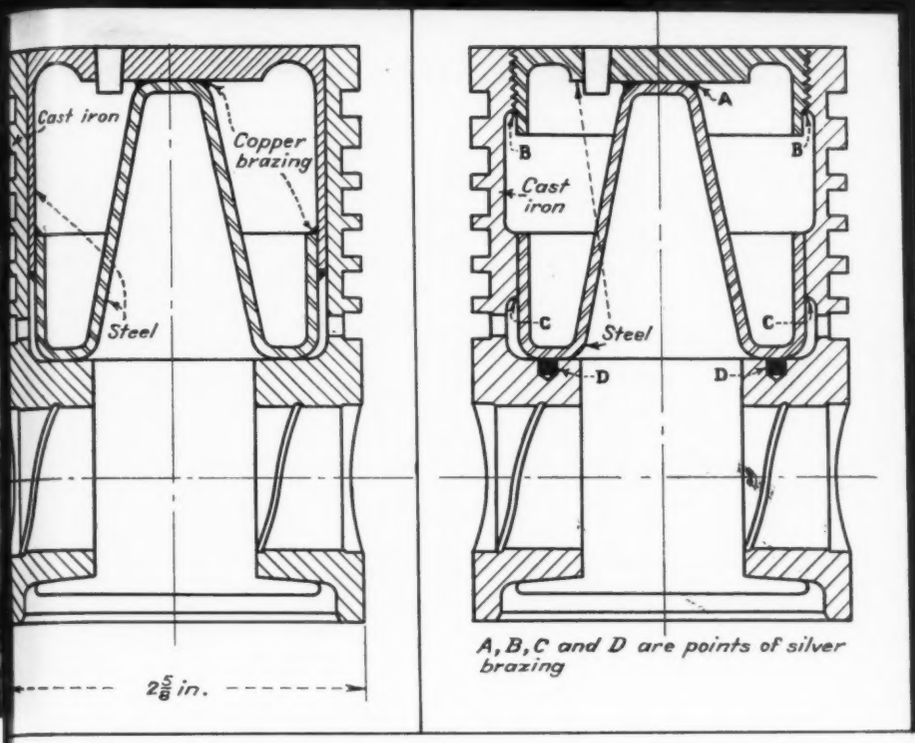


Fig. 3—(Left) An early (1938) attempt at creating a sodium cooled piston through hydrogen-copper brazing. Unsuccessful because of uneven contact between steel and iron. (Right) The same sodium-cooled piston with the construction redesigned for silver brazing has the required contact.

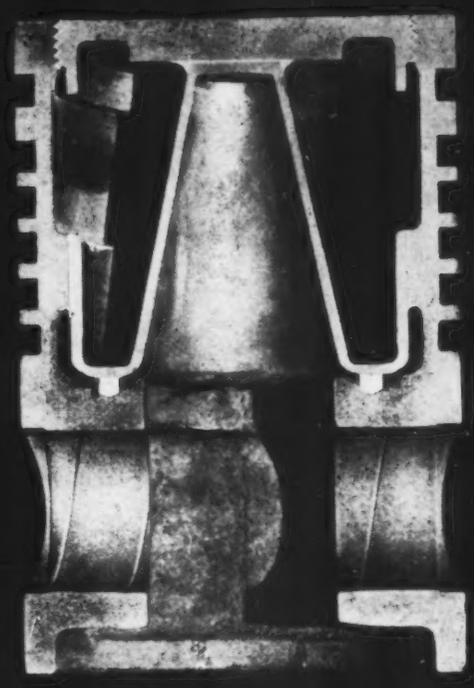


Fig. 4—The photograph has been retouched to show clearly how the silver brazing alloy flows by capillary action, filling every portion of the joint between the two materials.

Brazing of Cast Iron

HAROLD FRICK
Chief Engineer, Kolene Corporation

Joining cast iron to metals at temperatures that do not cause warpage. Built-up constructions and simplified castings are suggested. Good practice in joint design is discussed.

several parts to reduce coring. These parts are then assembled by silver soldering. Automotive engine blocks and heads can be and have been designed with this objective.

5. Machining in blind holes and narrow passages can be avoided by making the casting in two parts so that the machining will be done on an open face. After machining, the parts are sandwiched with a thin sheet of silver alloy between them and heated until the assembly is brazed together. This method reduces production cost.

In combination, these methods offer many possibilities for improving products and reducing foundry and machining costs.

Examples

COMPOUND CONSTRUCTIONS. A sodium-cooled steel aircraft piston was assembled to grey iron inserts by hydrogen brazing. Though the brazing was successful, it was expensive. Worse, the high temperature of the brazing operation changed the metallurgical structure of the grey iron so that it had undesirable bearing characteristics. Therefore the project was shelved. Later a sodium-cooled piston, having a cast iron body with steel inserts was desired for an unusual duty. Assembly by brazing seemed to be the logical solution but it was not considered a reliable process. The design in Fig. 3 (left) was evolved using a cast iron body with the sodium in a wrought steel capsule assembled by hydrogen-copper brazing. The capsule was then shrunk into the cast iron body. As might be expected, the uneven contact between capsule and body gave uncertain heat transfer and resulted in variable cooling characteristics. Although the design performed passably in World War II, it was evident that to secure highest thermal efficiency, the sodium should be in direct contact with a portion of the cast iron piston body.

A revised design, Fig. 3 (right) has been planned for silver brazing Assemblies produced thus far are sound and pressure tight because of the thoroughness of the bond.

To produce the piston the casting is roughed out all over, including pin bosses and ring grooves. Surfaces to be brazed are finished to size. All the parts are given the surface-preparation in a 850 F molten salt bath.

Complete rings of commercial silver brazing alloy wire, melting between 1,100 and 1,200 F are installed at points *A, B,* and *C*. Short pieces are placed at point *D*. The surfaces where a silver alloy bond is desired are fluxed with a commercial low melting flux. The assembly is then placed crown downward and heated to 1,450 F in an electric furnace. A city gas atmosphere is used to avoid scaling. Fig. 4 shows a half section through the finished product.

Thus from a simple casting and silver brazed inserts, a sodium cavity has been created. To produce this cavity by coring in a single casting does not appear to be commercially

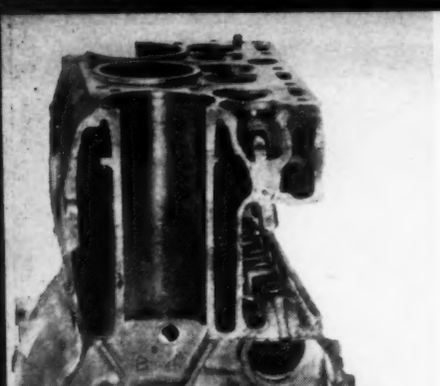


Fig. 5—A standard 6-cylinder engine block in cross-section. Coring cleaning are difficult.

Fig. 6—The same block bored out for redesign as a built-up construction. The foundry problem and inspection are much simpler in this construction.

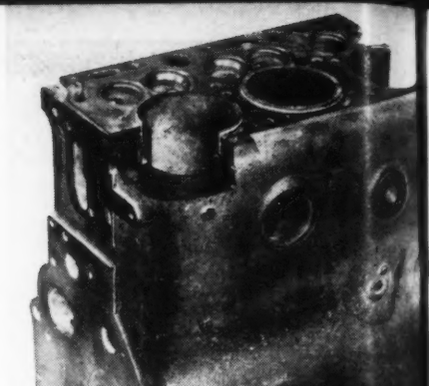


Fig. 7—After silver brazing separate sleeves in place. Uniform jacketing is now assured.

practical. This design is illustrated, of course, to show the possibilities of silver brazing rather than the design of a piston or type of piston.

SIMPLIFIED CASTINGS. Removal of cores in complex castings is often difficult and may be incomplete. In water jackets, an incompletely removed core may lead to cooling troubles. In engine blocks where cylinders are closely spaced it may be impossible to core a water space between them. Such siamesed barrels are undesirable from the casting standpoint and also have objectionable effects on piston and rings because of uneven cooling around the cylinder walls. It would be to the advantage of designer and foundryman to design the cylinder barrels to be brazed as an open block.

In Fig. 5 is shown a common 6-cyl, L-head engine block cut to show the complexity of the casting and difficult coring problem. Fig. 6 shows this block bored out, machined and prepared for the silver brazing of separate barrels. In Fig. 7, the block has been cut away after silver brazing. The photograph was retouched to show the effectiveness of the bond.

Some designers question exposing silver brazed parts to flame. This can be answered solely in terms of temperatures. If parts are water cooled, no trouble should occur. The melting points of silver brazing alloys are not far from those of aluminum alloys, which have been successfully used. On the other hand, exhaust manifolds that reach 1,300 F in service should not be silver brazed.

OTHER CONSTRUCTIONS. Many other economical and simplified designs are possible through silver brazing cast iron. Some commercially proven constructions, illustrated in Figs. 8 through 11, indicate applications.

Designing the Joint

JOINT CLEARANCE. The critical factor in joint strength is the amount of clearance. The chart in Fig. 12 shows

Handy Harmon, N. Y.

Fig. 8—Steel tubes are silver brazed to a malleable iron header in a portion of this barracks heating equipment.

Fig. 9—Diesel engine cast iron fittings above are silver brazed to steel tubing. The joints are stronger than cast iron fittings.

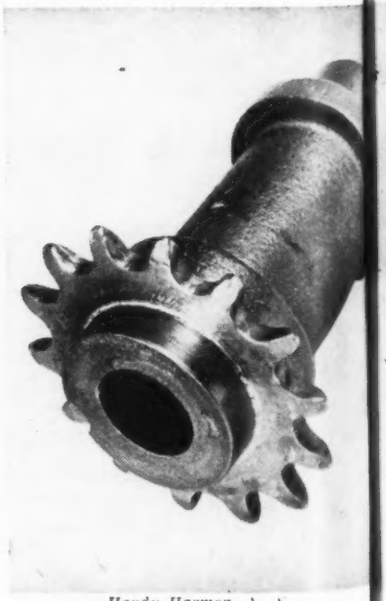


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Fig. 10—The steel sprocket is silver brazed to a cast iron hub on this part.

the relation of joint thickness to tensile strength. To obtain the relative strength of thick and thin joints, the material had to be sufficiently stronger than the brazing alloy to insure that the break would always come in the joint. The stainless steel had a tensile strength of 160,000 psi and the alloy, in 1/16 in. dia wire had a tensile strength of 62,000 psi. At one thickness, joint strength was in excess of 130,000 lb per sq inch.

No entirely satisfactory explanation of the cause of this greatly increased strength in thin joints has been found. Microscopic examination of the joints does not show that the diffusion of the silver alloy and the steel was of sufficient depth to affect over 5 percent of the thickness of the alloy. Diffusion alone, therefore, does not explain the phenomenon. The theory has been advanced that the limited area in a thin joint prevents free movement of the atoms in the brazing alloy in the direction of the tensile stress. Therefore the force required to produce rupture is greatly increased. Microscopic examination of the joints after testing shows that the brazing alloy has pulled away around the edges of the joint before breaking. This emphasizes the importance of bringing the joint members to a temperature that will insure a good bond with the brazing alloy. It also emphasizes the importance of cleaning the surface to receive the alloy.

In making a lap joint, a rule of thumb measure is to lap metals a distance of three times the thickness of the thinnest member. For example, to join a piece of metal 1/16 in. thick to a piece ¼ in. thick, lap should be 3/16 in. long. This would give a joint of a higher strength than the strength of the 1/16 in. piece.

As for proper tolerances to use on any of these types of joints, a space of 0.0015 to 0.003 in. between joint members produces the strongest joints. On small size tubular joints of about ¼ to ½ in. dia tubing these tolerances are easily held. The tolerances on larger size tubing would have to be greater. For example, on 24 in. dia tubing, a space from 0.010 to 0.015 in. or even 0.020 in. may be needed between the two members because of mechanical difficulties in fitting such large sections.

JOINT TYPES. Three types of joints are in general use—butt, scarf and lap or shear. The lap or shear type joint is generally recommended, although the others can be used satisfactorily under some conditions. Fig. 13 shows some commonly used joint designs.

BUTT JOINTS. There are some applications where the double thickness of a lap or shear type joint is undesirable. Here properly made butt joints can be used with good results, providing a few precautions are taken. The surfaces to be joined should be cut or machined square and even. When pressed together, the parts must provide the close clearance required to make joints of maximum strength. Joints of this design made under production conditions are strong and reliable if the parts are jigged so that clearance will be uniform over the entire area.

SCARF JOINTS. These are a special form of butt joint in which the surfaces to be joined are at angles of less than 90 deg to another surface of the parts to be joined. This type of joint is used widely in fabricating copper vessels and pipe and for such work as joining band saws. It provides high strength without making joint thickness greater than that of the metals joined. Joints are readily held in place by clamping while brazing.

SHEAR TYPE OR LAP JOINTS. These are the most satisfactory joints because any desired factor of safety can be incorporated by varying the lap shear area. This type of joint also offers better resistance to corrosion, since only a small area of brazing alloy is exposed. In adjoining flat parts a little pressure insures complete bonding. In shear joints that include tubular members, pressure cannot be applied and therefore cor-

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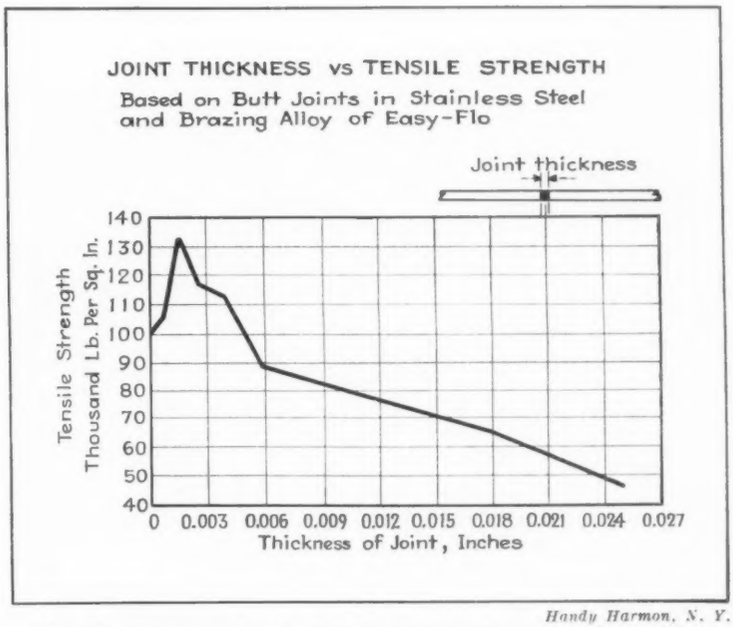
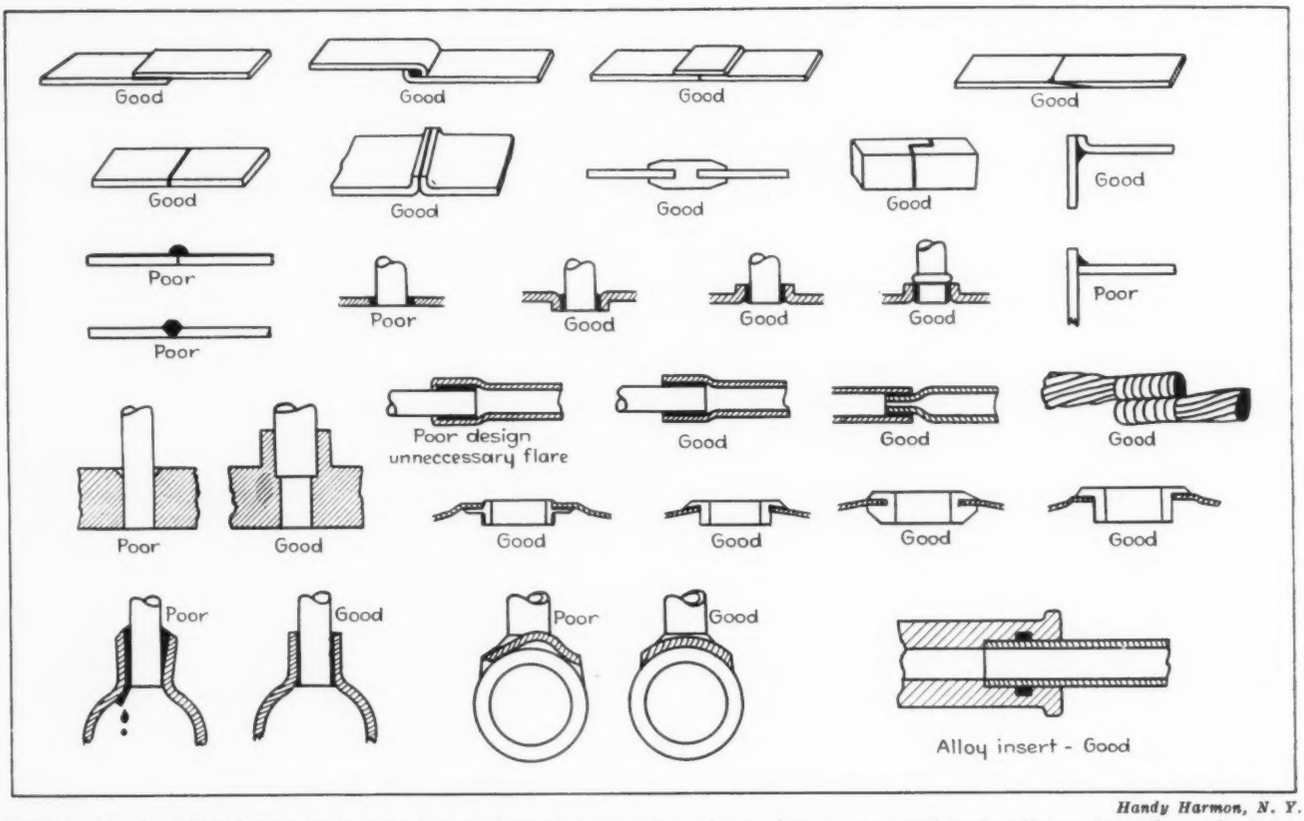
Fig. 11—Cutaway shows where steel tubing is silver brazed to a cast iron tripod leg. The assembly is induction brazed. Temperatures are moderate.



Handy Harmon, N. Y.

Fig. 12—Clearance is of vital importance in a silver-brazed joint. Strongest joints occur with clearances of 0.0015 to 0.003 in. Large sections may require larger clearances for production.



Handy Harmon, N. Y.

Fig. 13—Good and bad practice in oint design. Essential point is to keep clearances small and uniform throughout the joint.

rect clearances for capillary action are the critical design factors.

The depth of shear required will vary according to the strength of the metals being joined and the factor of safety wanted. The method for computing the shear area is discussed in an article in PRODUCT ENGINEERING, June 1945, p. 412.

Joint Cost

It is frequently assumed that silver brazing is an expensive process because the cost of silver alloys is often about ten times that of 60 copper 40 zinc alloys.

A true picture of costs cannot be gained by comparing the cost of brazing alloys per pound or ounce. The only accurate basis is to compare the cost per joint in production. Brazing alloy costs are but part of total costs and often a surprisingly small part. Labor and materials, including gases, metals, production rates, cleaning and finishing expense are also important factors.

Production brazing must be performed, for safety's sake, at about 150 F above the brazing alloy melting point. Minimum operating temperatures then become about 1,325 F for silver alloys and 1,800 F for 60-40 alloys. A brazing temperature of 1,800 F for a complex iron casting is often not allowable because of distortion, softening and deterioration in properties.

Apart from warpage, the costs of heating from 1,325 F to 1,800 F are considerable. Not only does the extra heat cost money, but the initial cost of the higher temperature furnace is greater than for the lower temperature furnace.

It takes less time to heat silver alloys to 1,300 F than to raise other brazing alloys to their flowing points. Fast penetration also speeds up the actual making of a joint. The time savings mean lower labor expense and less gas consumption. Thin films of alloy 0.001 to 0.003 in., with no need for large fillets, keep brazing costs per joint at a low figure. Because silver alloy joints are so strong, the lap required by other methods often can be reduced. This saves metal, which is important when joining copper or an expensive alloy. Where joint appearance counts, silver alloy brazing keeps finishing expenses low. The fine line or small smooth fillet at the joint often needs no more than a final polishing. When properly applied, joints are free from gas pockets or flux inclusions. This reduces rejects to a minimum.

Based on prices as of February 1947, a brazing alloy containing 50 percent silver sold for 46.25¢ per oz. in lots of 10,000 oz. and in the form of $\frac{1}{32}$ in. wire. One troy ounce of this size contains 264 in. of wire. Thus an insert ring for a 1 in. dia tube joint costs about half a cent.

• • • •

IN 1798 it was inconceivable that guns could be made in any other way than by laborious handwork. Each complete gun was made as a separate unit, no two of which were ever the same. Eli Whitney was convinced that by making each part of a large order of guns alike, there could be interchangeability and low cost. To prove his contention, he took the parts of ten muskets to the War Department, and after spreading them out, chose the different parts at random and assembled ten muskets. It was an amazing feat. The officials were astonished to see the possibility of each musket identical with the others. Whitney completed a contract for 10,000 muskets in the year 1808. Thus began the principle of mass production of identical interchangeable parts.

ENGINEERING ABSTRACTS

FOREIGN AND DOMESTIC ARTICLES

Lightweight High Pressure Hydraulic Systems

Foreign abstract condensed from the "Development of Ultra High Pressure Hydraulic Systems" by S. M. Parker, presented before the Institution of Mechanical Engineers, January, 1947.

THE FOLLOWING DEFINITIONS are suggested as descriptive of this equipment: up to 500 lb. per sq. in., low pressure; 500 to 1500 lb. per sq. in., medium pressure; 1500 to 3000 lb. per sq. in., high pressure; 3000 to 5000 lb. per sq. in., ultra high pressure. The first three ranges are in common use, but in the lighter forms of engineering the ultra high pressure range has hardly been used at all. Ultra high pressure offers possibility of reducing weight and bulk without departure from necessary standards of reliability, ease of maintenance and cost.

Temperature Range Required

A figure of 120 deg. C. (248 deg. F.) is suggested with suitable adjustment of the mean point for different applications. In aircraft systems normal operation must be achieved between 158 deg. and −58 deg. F., in industrial applications maximum temperature may be 212 F. with lower temperatures correspondingly reduced. Even for automobile work, assuming the same fluid for all climates, little reduction is possible. To meet these working temperatures it is desirable that variation of 36 deg. F. either way should not cause complete stoppage of the system even though it may work less efficiently. At the highest temperature the fluid must not vaporize appreciably, nor must its lubrication properties fall below the minimum necessary in a power pump; at the lowest temperature its viscosity must not rise to a point at which transmission losses become unacceptably high.

Hydraulic systems have a property that is different from electrical and mechanical systems, and that has a most important effect on the above problem. At peak load, when pressure from the power source is just slightly greater than pressure required by the hydraulic motor, flow will be at a minimum and transmission efficiency approaches 100 percent. Therefore, high average losses in hydraulic systems are tolerable and sometimes even desirable to achieve a simple form of speed regulation, because they disappear at peak loading. This feature provides flexibility and ability to withstand overload. If the system is supplied with a constant pressure, an average balance of 40 percent will be available to overcome mechanical friction, to provide the necessary acceleration of masses, and to allow for line loss. By careful design, friction losses can be kept at less than 5 percent and often as low as one percent. The acceleration forces involved in moving masses of a few hundred pounds through only a few feet in several seconds are practically negligible and, therefore, practically the whole of the 40 percent is expended in line loss. In a high-pressure system losses in the order of 1000 lb. per sq. in. in pipe sizes of 0.2 in. dia. and in circuits 10 to 20 ft. long, limit fluid viscosity to a maximum of 500 to 1000 centistokes; this viscosity being approximately that of medicinal castor oil at room temperature. In an ultra high-pressure system the percentage of line loss can remain the same, and the loss per foot of run be almost doubled, thus permitting smaller bore sizes, but not affecting to any appreciable extent the permissible viscosities. The engineer desires a fluid that changes viscosity to the least possible extent over the working range of temperatures. At present a change of at least a hundredfold has to be accepted. One of the new silicone types, now in the early stages of development, has a viscosity change that is only about ten fold and thus offers great advantages.

The upper limit of use of a fluid is determined by the vaporizing point of the most volatile constituent. In mineral oils this is generally a small percentage of the volume, and in castor base fluids it may be as high as 80 percent. Therefore, with castor base fluids it is desirable to have a margin of about 72 deg. F. between operating temperature and vaporizing point.

The fluid having the lower viscosity is not always best from a transmission efficiency viewpoint. In the high-pressure system used in aircraft, losses with mineral oil at 20 centistokes are much the same as for castor base fluid at 10 centistokes, because the former is still laminar flow while the latter has become turbulent. The use of ultra-high pressure will not affect greatly this relationship, but if electrical control circuits make hydraulic systems more compact, the length of piping will be reduced. Since there is no purpose gained in reducing line losses below a quite substantial level, it is inevitable that large increases in linear rates of flow will take place. Then both mineral oil and castor base fluid will give turbulent flow, and viscosity will be of greater importance. At lower temperatures in particular, there will be a big advantage for the least viscous fluid.

Pipe Materials

On a strength/weight basis, aluminum alloy is to be preferred, but it is not sufficiently ductile to permit the reliable use of flared fittings, and it is too soft to give good security with compression type fittings. Technical improvements in such alloys or the use of magnesium may in time alter this position, but for the immediate future steel pipe will continue to give good service in ultra high pressure systems because the security it gives either with compression or flare joints is second to no other material. The flared joint now used was originally designed for low-pressure work and will not, in its present form, provide adequate strength. The redesign of hydraulic fittings will be necessary.

Control valves are mainly of the poppet valve or slide-valve type. With the former, the difficulty lies in balanc-

ing the hydraulic load sufficiently to make manual operations or remote operations reasonably light, and in the choosing of mating materials soft enough to provide a good seal at low pressure and of adequate strength at high pressures.

Static balance is easily achieved with slide valves of the piston type, but dynamic out-of-balance effect and what may be termed power filtration, or the wedging of small impurities in the fluid into the working clearances, will be more noticeable. In replanning the hydraulic system, electrical remote control will greatly reduce weight and this result completely swamps the more modest gain that results from the use of ultra high pressure. A saving of 4 to 5 percent of the total system weight should be achieved in transmission and controls.

Power Generation

Development indicates that a figure of 2 hp. per lb. can be achieved at 5000 lb. per sq. in. with the same minimum weight of 5 lb. The best design of hydraulic pumps should have an overall mechanical to hydraulic conversion efficiency of better than 90 percent. It should be possible to reduce considerably the volume of fluid carried in the supply tank and this will be the greatest contribution towards decrease of weight and bulk that can be derived from increased pressure; approximately 3 percent of system weight.

Present high-pressure equipment at 2500 lb. per sq. in. has little to spare in the way of reliability if it is coupled with high efficiency. As pressures increased jack diameters decrease in proportion and piston rods which must be considerably smaller than jack diameters decrease also. A point is reached where, even if they are solid they fail to provide adequate strength. This will affect the length of piston rods and users of hydraulic equipment may not be willing to accept the reduced jack travel.

From the functional standpoint the major problem is that of suitable sealing, particularly the moving seals. It is not the function of a seal to prevent any passage of fluid, because parts moving under heavy loads cannot work continuously without lubrication. It is imperative to recognize that seals must permit the passage of a minute, but finite film of lubricant. Yet this must be controlled so that it cannot be termed a leak. At 2500 lb. per sq. in. and over, working pressures are in the same order as the rupturing strength of the material being used, so that a seal good enough to prevent lubrication will

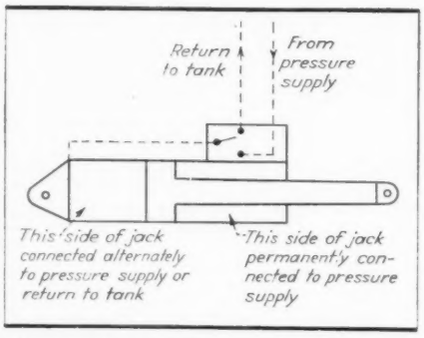

Return to tank
From pressure supply
This side of jack connected alternately to pressure supply or return to tank
This side of jack permanently connected to pressure supply

Fig. 1—Diagram of suggested hydraulic pack of improved dif design.

suffer additional friction effects that are additive to its direct loading. It will lead to rapid disintegration. Extrusion effects which are not unknown with stationary seals at high pressures indicate the small margin of strength possessed by many rubber compoundings. Fabric reinforcement helps, but frequently this increases friction and thus a vicious circle is completed, often inacceptable for sensitive mechanisms. The solution may be to accept a small but finite leak to achieve lubrication and to add a low pressure seal between the leak and atmosphere. But the structural strength of a jack must be considered first. Tensile effort of the jack should not be less than 75 percent of its extending thrust. This limits the diameter of the piston rod to a maximum of half the diameter of the jack. The stroke/bore ratio required at 2500 lb. per sq. in. varies between 4 to 1 and 6 to 1 for small jacks and up to 8 to 1 and occasionally 10 to 1 for large jacks. It is one that offers the user at least 6 to 1 without appreciable weight penalty, and 8 to 1 if the penalty is accepted. The piston rod will, therefore, have a ratio that is twice this figure, namely 12 to 1 and 16 to 1. To utilize material efficiently the section thickness should not normally exceed 10 percent of the diameter with 15 percent maximum. Allowing a working factor of 2, the crippling loads correspond to a working pressure of 2600 lb. per sq. in. for a 6 to 1 stroke bore ratio jack. Thus it is clear that a working pressure in the region of 5000 lb. per sq. in. is not possible. There is a solution if the size of a jack for a 2500 lb. per sq. in. system is retained for a 5000 lb. per sq. in. system.

If both sides of the jack are connected to the pressure source, the jack will extend against a force equivalent to the difference of areas of the two sides; or the area of the piston rod. Thus rod diameter can be increased by 50 percent, thereby allowing more efficient use of material. At 5000 lb. per sq. in., the piston rod will be lighter than at 2500 lb. per sq. in. The cylinder tube will be somewhat heavier, but other parts will not be affected greatly. This arrangement allows the mounting of a control valve on the jack itself and the valve only controls flow to or from one side of the jack, since the other side is constantly connected to pressure. It is apparent that the flow in each line is unidirectional as shown in Fig. 1 and one line only is subject to full pressure. The return line can be of reduced thickness as it deals with low presures only. It is doubtful that ultra high pressure will show weight savings in the jack itself, but savings in other parts of the system should show a net of 5 percent over a high pressure system. This design of jack, having a permanent low-pressure line attached, lends itself particularly to the gland arrangement mentioned previously. Leakage from high pressure seals can easily be taken away without extra piping.

Conclusion

None of the savings mentioned in the three sections is of spectacular size, but in the aggregate pressure increases from 2500 to 5000 lb. per sq. in. in light hydraulic systems would reduce the weight of aircraft equipment by about ten percent. This is not to be confused with a further saving of the same order that should arise from more intelligent planning of the system as a whole, irrespective of the pressure. The size of components and pipes would be appreciably reduced and reliability should not be decreased. In the author's opinion light hydraulic engineering has reached the stage where indecision is indefensible.

Thermoplastic Laminates

From "Thermoplastic Laminates" by R. J. Metzler and L. T. Barnette, Hercules Powder Co., presented at Pacific Coast Section, Society of the Plastics Industry, March, 1947.

CELLULOSE-DERIVATIVE LAMINATES make up a family of products rather than a single product. The properties can be varied over a wide range from flexible to rigid, depending on the type and amount of plasticizer used. Further variations can be made through use of fillers or reinforcements selected from a broad variety of available fabrics and textiles.

The cellulose-derivative plastics are known for their extreme toughness. Their strength generally is doubled on

lamination with fabrics. By selecting special textiles such as glass for lamination, the impact strength of the base cellulosic plastic can be tripled and in some cases quadrupled. Color possibilities, as in molded articles, are unlimited when the binder is based on either cellulose acetate or ethyl cellulose. Printed textiles, for example, can be embedded in a clear laminate to create decorative effects.

Another feature of these materials is the ease with which finished articles can be fabricated. Heat-forming and deep-drawing from flat sheets without complex or expensive equipment are possible. Since these materials can be either solvent-sealed or heat-sealed, operations such as drilling, punching, and riveting are not usually required, although they can be performed readily if desired. No additional protective or decorative coatings are required because of the color and finish of the laminate.

The effects of various textile fillers on the properties of cellulose acetate laminates made by the heat and pressure process have been studied. The plastic composition and the ratio of plastic to cloth were held constant. The results obtained indicate that cloth when used as a reinforcement gives greatly added strength and that the type of fabric used can have a definite bearing on the properties of the laminated structure. Glass fabric yielded an interesting laminate. Extraordinary high impact strength was combined with high tensile strength, high elastic modulus, and relatively low water absorption.

The laminate based on kraft paper had unusual strength properties, when compared with other cellulose-derivative laminates, with the exception of impact. However, this value was good when compared with similar values for paper-base phenolics. These were all edgewise determinations, and would have been much higher if flatwise specimens had been tested. Asbestos paper gave a laminate with properties remarkable in many respects. An elastic modulus of nearly 2,000,000 lb. per sq. in. was significant.

An interesting characteristic of these materials is the high energy absorption they exhibit. Very little vibration is transmitted by or through the laminates. In addition to versatility of color and of fabrication, the physical properties can be varied over an extremely wide range by proper selection of laminating materials.

Suggested uses for thermoplastic laminates are: Suitcases, electrical housings, portable and experimental loud speaker housings and miscellaneous cases, large spheres (10 feet in diameter), expendable gas tanks, air vents and fairings for airplanes, inside refrigerator panels, automotive arm rests, automotive seat trim, automotive door panel bases, sun visors and business machine covers.

Lead, Zinc, and Tin for Coating Metals

From a paper "The World Situation on Coating Materials, Lead, Zinc, and Tin" by C. A. Ilgenfritz, vice president of Purchases United States Steel Corp. of Del. presented May 21, 1947 before the American Iron & Steel Institute, New York, N. Y.

SUPPLIES of the three principal coating metals used in the steel industry—lead, zinc, and tin—are today high on the list of hard-to-get metals. Relief cannot be expected until supply and demand are in balance, and many factors are involved in shaping the answer as to how soon this balance will be attained. The following conditions are world-wide in scope.

LEAD. Lead ore is produced principally in the United States, Canada, Mexico, Australia, Germany, and Burma. It is reported that the United States has approximately 14 per cent of the world's lead-ore reserves which, it is estimated, will last only 12 years based on the 1935-1939 annual rate of consumption.

Supplies of lead have been very precarious since the end of the war and are extremely critical now. Facing heavy reconstruction needs, Western Europe could not draw on its normal pre-war sources, Silesia and Jugoslavia, whose entire output now goes to Russia. As a result, this requirement was transferred to mines in Australia and the Western Hemisphere. This sharply affected United States lead imports, which were considerably less than in 1945, most of the tonnage coming from Mexico, Canada and Peru. Australian lead, shipped here during the war went to Great Britain in 1946.

Refinery capacity at the close of 1940 was 2,200,000 net tons outside and 1,068,000 net tons inside the United States. Five years later capacity here had dropped to 975,000 net tons, with Missouri alone accounting for about 24 percent. Since 1939, there has been very little new plant construction here, while some of the foreign producing units suffered heavily during the war. This was especially true of the famous Baldwin Zinc-Lead Mine and Smelter in Burma, which had produced 75,000 tons of lead per year before the war.

ZINC ores are found in various parts of the world, principal producing countries being United States, Canada, Mexico, Australia, Germany, Italy, and Newfoundland. All these, except Newfoundland, operate distillation or electrolytic zinc plants.

The United States is credited with approximately 19 percent of the world's zinc-ore reserves. It is estimated these reserves will last 19 years at the 1935 to 1939 annual rate of consumption. As with lead, the United States is the world's largest producer of zinc and also the largest consumer of this metal.

Zinc supplies are tight and likely will continue scarce as long as domestic consumption stays at the existing high level and until production in foreign countries picks up. Lack of fuel is holding production in Belgium to about 75 percent and in France and Norway to about 50 percent. Higher prices abroad are attracting zinc from Mexico which normally is shipped to America.

TIN. The United States is not a producer of tin ore, but since 1942 government-financed plant at Texas City, Texas, smelts ore from foreign countries, mostly from Bolivia.

Tin ore is found in widely scattered parts of the world, but is produced in quantities in relatively few countries. The principal ore-producing countries are Malaya, Netherlands East Indies, Bolivia, Nigeria, Belgium Congo, China, Siam, French Indo-China, and Burma. In the five year pre-war period, 1935-1939, Malaya accounted for about 33 percent, Netherlands East Indies about 18 percent and Bolivia about 15 percent of the world's supply of tin contained in ore. In some instances, smelters are located in close proximity to the ore deposits, whereas in other instances the ore is transported quite a distance. As an example, Bolivia, which has no smelting capacity,

ships her entire production of tin ore to other countries, principally to the United States and England.

World tin production is improving, but progress will be slow. The 1947 output is estimated at 50 percent of the pre-war rate and, while 1948 should show continued improvement, full production is not expected before 1949. Meanwhile, it probably will be necessary to continue some restrictions on tin uses to insure supplies for the more essential needs.

Most of the world's production of tin is used for coating materials by the hot dip or the electrolytic process. The trend is strongly upward in the production of electrolytic tin plate in the United States. Last year about 36 percent of the tin plate produced here was by the electrolytic process and 64 percent was hot dipped. A projected estimate indicates that by 1950, electrolytic tinning may increase to about 66 percent with hot dipped dropping to about 34 percent of the total coated products made. Tin is also used in the manufacture of solder, babbitt, bronze, collapsible tubes, and a number of other important commodities.

Before the war, United States manufacturers used 39 percent of the world's total production of primary tin, and of this amount about 53 percent was for protective coatings. On a non-restrictive basis, it is estimated tin users here will require 85,000 gross tons while world requirement will be 195,000 gross tons of primary tin annually. Some reported figures sound fantastic, such as the one that world tin consumption may some day reach 250,000 tons annually. World production of primary tin in 1946 was some 87,000 gross tons and consumption was 115,000 gross tons.

Stocks in the United States held by private industry and the government declined approximately 14,000 tons during 1946. There will be a further decline this year. Even if controls are continued, indications are that government reserve stocks, exclusive of those held for permanent stockpiling, will be exhausted by the end of 1947. It is anticipated that world stocks will reach a low of about 40,000 tons by January 1, 1948. There will be a slight improvement during that year and the stock on January 1, 1949, should be about 48,000 tons. It will probably be a year later than that before we have a good world-wide supply. The progress made in rehabilitating the tin-producing countries in the Far East will determine how soon we shall return to a normal position in the United States.

Characteristics of Welding Tools

From "Electrical Characteristics of Resistance Welding Tools" by E. M. Callender, The Budd Company, presented at A.I.E.E., Jan. 1947, New York, N. Y.

Time saving methods of measurement and calculation of resistance welding tools have been developed, especially for non-standard type portable welding guns. Electrical characteristics affect: (1) The kva at an installation, (2) required secondary voltage of the welding transformer, and (3) efficiency of the tool, and tabulated results include typical measurement data, detailed results of tool measurements, and comparison of measured and calculated values.

By practical necessity the average resistance weld is made in a lengthy looped circuit that gives rise to high kva de-

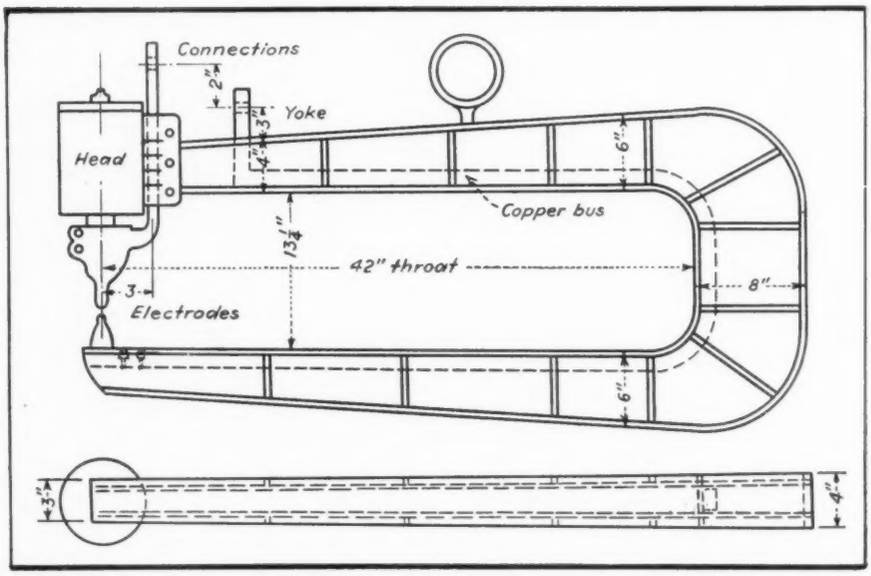


Fig. 1—Typical large size welding tool of stainless steel with copper bus inside.

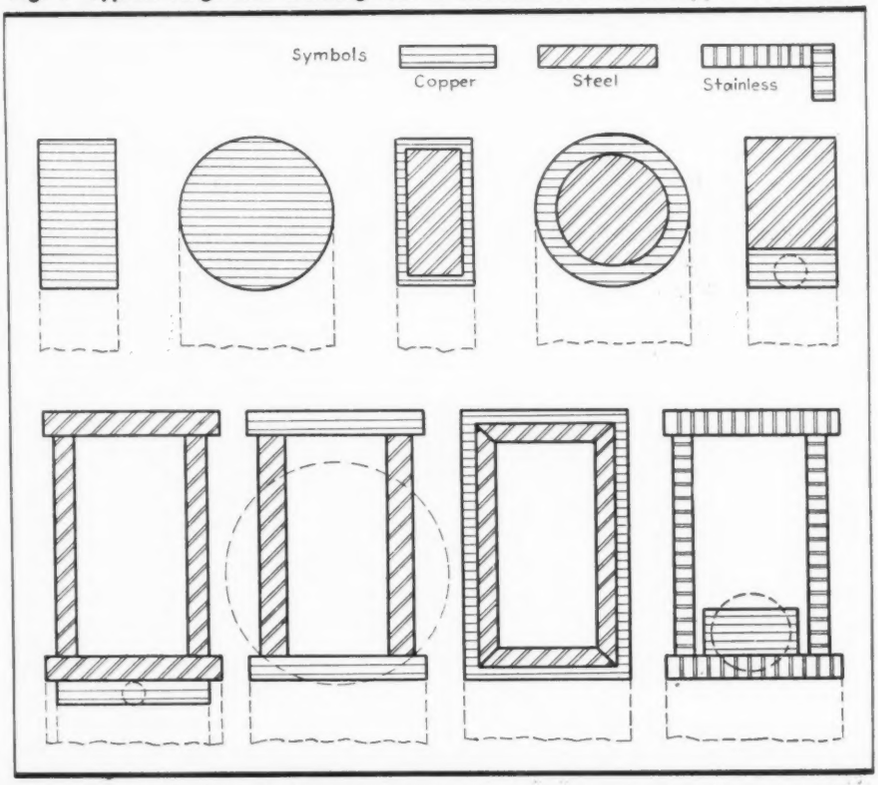


Fig. 2—Cross sections of different welding arms composed of various materials.

Table I—Electrical Resistivities of Welding Tool Materials

Welding Tool Material	Resistivity at Room Temperature, Microhm—cm³	Magnetic Susceptibility*
Elkaloy A (Wrought)	2.05	Diamagnetic
Mallory 3		
Cast	2.15	Paramagnetic
Wrought	2.3	Paramagnetic
Mallory 53		
Cast	4.3	Paramagnetic
Wrought	4.3	Paramagnetic
Mallory 73		
Cast	8.6	Diamagnetic
Wrought	7.5	Diamagnetic
Mallory 100		
Cast	3.8	Paramagnetic
Wrought	3.45	Paramagnetic
Copper		
Cast**	2.15	Diamagnetic
Wrought	1.75	Diamagnetic
Typical high tensile maganese bronze	12.5 percent conductivity in percent IACS	
Typical aluminum bronze (equal to ampco 18)	12.2 percent conductivity in percent IACS	
Typical aluminum bronze (equal to ampco 21)	10.2 percent conductivity in percent IACS	

Other materials used for spot welding electrodes for high resistance work sheets, or for projection welding, flash welding and butt welding dies.

Elkonite Grade		
10W3	5.75	Paramagnetic
20W3	5.95	Paramagnetic
3W53	5.75	Paramagnetic
10W53	6.15	Paramagnetic
TC–5	3.65	Paramagnetic
TC–20	5.4	Paramagnetic
TC–53	8.6	Paramagnetic

* Essentially the permeabilities are in the order of unity for these materials.
** Electrical resistivity of copper castings varies rather widely and is dependent upon the degree of deoxidation, type of deoxidizer, and the amount of residual deoxidizer in the casting. The value given is typical of a so called high quality casting.

mands, low power factor, and large inefficiency. The load itself, comprising two or more pieces of relatively thin sheets to be welded, is frequently an insignificant part of the total secondary circuit resistance. The characteristics of permanent type welders are available from the manufacturer in many cases. However, the welding engineer, both designer and user, often has a vital interest in the large class of welding tools known as portable welding guns, whose installations include water-cooled cables of four to twenty (or more) foot lengths. The reason these cannot be standardized is that a vast number of specialized yokes (welding arms of such guns), such as shown in Fig. 1, are required to reach into all the spots that require welding by the builder of large sheet structures. The impedance of the welding transformer secondary circuit is vital both to users who must select the proper rated welding transformer for the job and to designers who seek to provide better efficiencies and power factor loads. The values shown in Table I also are significant.

Compared to the usual highly theoretical calculation of inductance, the approximate calculation and semi-empirical approach is quicker, is accurate enough, simplifies the problem imposed by variation in cross section of arm, and to a degree avoids some of the practical errors that creep into a strictly mathematical analysis. The system of a.c. measurement for determining values of low order impedance, resistance, and reactance of welding tools and cables, is useful in correlating and verifying calculated values.

The a-c system of measurement explained in the paper provides reasonably accurate measurements of the low order of impedance, resistance, and reactance of cables, of great value in correlating the mathematical work.

Characteristics of Steel for Tubular Products

From "Physical Characteristics of Steel for Tubular Products", by A. B. Wilder, National Tube Company presented at the June, 1947 meeting of the American Society for Testing Materials.

SOME OF THE FUNDAMENTAL FACTORS in steel making that influence the impact strength and age hardening characteristics of acid bessemer, basic open hearth and certain grades of electric furnace steel used in the manufacture of tubular products were investigated. The tests included grain size determinations, high temperature tensile tests and Charpy impact tests for toughness.

The steel samples used in the test were from commercials heats of steel that met the requirements of standard A.S.T.M. specifications for tubular products. The majority of the tests were made using as-rolled pipe except for the alloy steels, which had been subjected to conventional heat treatments. The conclusions reached were:

1. The carburized austenitic grain size at 1700 deg. F. was consistent with the deoxidation practice employed. Capped, semi-killed and silicon-killed steels had coarse grain structure. Silicon-aluminum killed steels had fine grain structure.

2. Deoxidized acid bessemer steel had the highest grain coarsening temperature and the most uniform grain size.

3. Tensile test results at 450 deg. F. indicated that as-rolled material was susceptible to age hardening. Normalized deoxidized acid bessemer and silicon-aluminum killed open hearth steels did not age harden.

4. The Charpy impact properties of deoxidized acid bessemer and silicon-aluminum killed open hearth steels normalized at 1950 F. were superior to capped and silicon-killed carbon steels.

5. Charpy impact properties in the as-rolled condition without cold deformation were similar in a temperature range from minus 50 deg. F. to plus 150 deg. F. for the deoxidized acid bessemer, silicon-aluminum killed open hearth and electric furnace steels. In the noramlized state, 1650 deg. F., deoxidized acid bessemer steel had the highest impact strength.

6. Impact properties after cold working pipe in the as-rolled condition were similar in the deoxidized acid bessemer, semi-killed open hearth, silicon-aluminum killed open hearth and silicon-killed open hearth steels. The capped steels were at a slightly lower level and the electric furnace steels were at a slightly higher than the other steels.

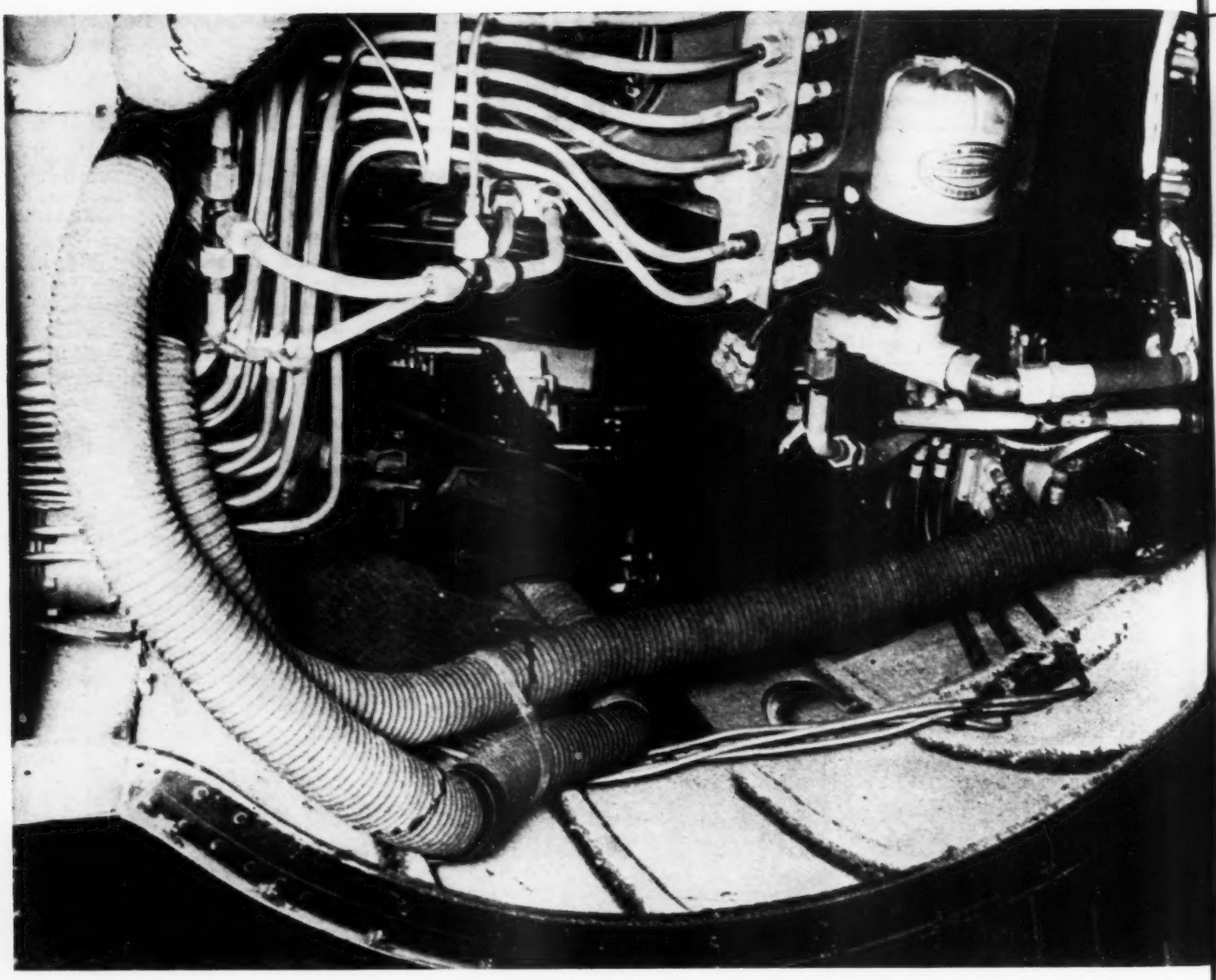


Fig. 1—Flexible nonmetallic ducts were used for many heating, deicing, defrosting and cooling applications in war aircraft.

Air Ducts of Nonmetallic Materials,

WATSON G. HARDING
United States Rubber Company

LIGHTWEIGHT, nonmetallic air ducts, widely used in aircraft, are presently finding new applications in buses, factories and on machinery. Automobiles, railway cars and ships are other potential uses. Originally, corrugated nonmetallic ducts were developed during the war concurrently with making breathing tubes of gas masks for horses. For this purpose a light, flexible, crush-resistant tube was required. Wire or metal was avoided in the design and construction of the duct not only to gain lightness in weight but also because of the shortage of metals. Initially, flexible sections of the nonmetallic ducts were installed in aircraft in combination with metal ducts to replace flexible metal tubing. The natural evolution was a demand for rigid as well as flexible sections so that eventually the air-duct systems in many trainers, fighters, bombers and transports became completely nonmetallic. When used in power plant installations, for applications such as generator blast tubes, these nonmetallic systems proved to have a remarkable resistance to fatigue from vibration.

Asbestos, glass or cotton fabrics depending on the service requirements, combined with synthetic rubbers and synthetic resins are the materials commonly used in nonmetallic ducts. From them ducts can be made that are heat and fire resistant. Further, they have the property of dissipating rather than transmitting the noise from vibration. Ducts made of cotton fabrics can be used where the service temperatures do not ex-

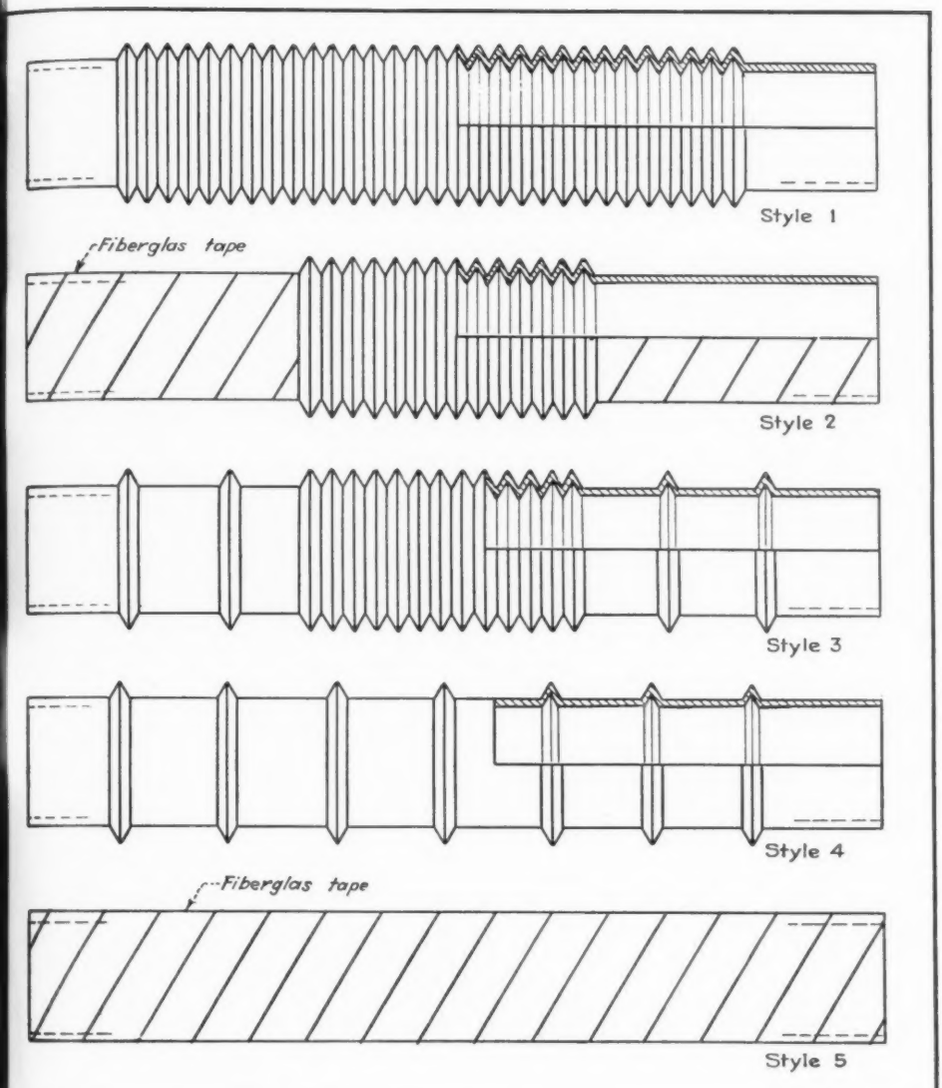


Fig. 2—Five styles of flexible and rigid Multi-Flex ducts for aircraft applications.

Types and Applications

ceed 250 deg. F. Ducts made of asbestos fabrics can be used for temperatures up to 350 deg. F. For higher temperatures, glass fabrics are necessary. Glass fabric ducts are often specified for service within the 250 to 350 deg. temperature range, particularly when light weight is also a requirement.

Ducts are formed to length over plain mandrels, which can be round, oval, rectangular or most any desired cross section. Single and two-ply constructions are customary. Processing the inside surface, or between plies, with synthetic rubber closes the pores in the fabrics. Resistance to crushing and the degree of flexibility of a duct are built into the outer layer or cover.

Up to the present time no society or group of manufacturers, either for the sake of interchangeability or because of pressure from another body, such as the airplane manufacturers or an agency of the government, has attempted to standardize the sizes and qualities of nonmetallic ducts. In one respect standardization is less essential to interchangeability for nonmetallic ducts than for metal products.

Nonmetallic ducts have been largely tailor-made products. They are made as parts to customer drawings and specifications just as metal stampings or castings are made. Customers design them to fit the spaces. The mandrel comprises the only tooling expense so that economy of production is not affected greatly by the quantity required. Intercompany consideration of standardization therefore may well be postponed until that time comes when nonmetallic ducts need to be stocked like sheet-metal ducts for hot air furnaces or as replacement parts like automobile tires.

Construction and Materials

The Author's Company manufactures Multi-Flex ducts, which are nonmetallic ducts made in accordance with a patented process. Although the sizes and qualities of these Multi-Flex ducts have not been standardized, specific data about them are typical of all nonmetallic products. At the same time they represent data that are universally applicable in the design of air flow systems for vehicles and machinery.

Five styles of aircraft Multi-Flex ducts are shown in Fig. 2. Style 1 is flexible throughout. Styles 2 and 3 are flexible in the sections having multiple corrugations and rigid in the sections that are shown as wrapped with glass fabric tape or having single corrugations, which have a relatively hard surface finish to provide rigidity. Styles 4 and 5 are rigid throughout. Both the tape and the single corrugation construction are used, either because of customer preference, or because certain materials or combination of materials do not lend themselves to both types of construction.

Style 5 is constructed in only one way, consisting of two plies of lightweight glass fabric and a cover of glass fabric tape. The other four styles are regularly made in several constructions, Table 1. The letters A, B, C and D, following the style numbers, define the fabrics. The letter S indicates a softer outer finish, which means for instance, that style 1-AS, is the same as style 1-A except that 1-AS offers less resistance to crushing.

Cotton fabric ducts weigh about the same as the ducts of medium weight glass fabrics of an equal number of plies. Except for the tempera-

ture limit of 250 deg. F., the properties of Table I apply to cotton ducts. Nonmetallic ducts are suitable for exhaust systems of slight and moderate negative pressures and for slight to moderate internal pressures. Large ducts with more flexible finish will collapse at fewer inches of water pressure below atmospheric than small ducts with hard finish. The corrugated and rigid sections resist internal pressures about equally well; the corrugated sections resist negative pressures better than the straight sections.

Since the successful design of air flow systems, especially exhaust systems, depends mainly on how nearly correct the resistance to flow is estimated, friction factors, F, are given in Fig. 4. Let

P = pressure drop, inches of water;
L = length of duct, ft.;
D = inside diameter of duct, in.;
V = rate of air flow, ft. per sec.;
S = specific gravity of air referred to standard air at 0.075 lb. per cu. ft.;
F = friction factor, Fig. 4

then

$$P = 0.0027\ FLS\ V^2/D \qquad (1)$$

A common practice is to double the friction factor for that length of the system made up of bends, tapers, tees and connections at hoods and blowers. In the design of a complete system, there must be added to this the resistance of grids, resisters, fans and other units in series with the ducts. Additional allowance must be made for adjustable sections such as a flexible portion to carry dust from a movable grinding wheel into an exhaust system. Such resistances are not easy to estimate even with a fair degree of accuracy. Needless to say an experimental verification of a complex exhaust system is as practical for a system having nonmetallic ducts as for one that has metallic ducts.

Metal exhaust systems frequently are objectionably noisy. The usual method of reducing the noise is to insulate the fan from the supporting structure with rubber, cork or composition pads and to isolate the fan from the metal ducts with a flexible joint. Nonmetallic ducts inherently suppress the noises transmitted to them by fans and blowers.

Cylindrical sleeves, either metal or plastic, are convenient in making permanent joints in nonmetallic ducts. A sleeve length of half the duct nominal diameter and not less than 1¼ in. has been satisfactory. If the sleeve is from 0.020 to 0.050 in. larger in diameter than the inside of the duct, a press fit is obtained. A quick-acting plastic coupling has been found convenient in connecting ducts for temporary installations.

Table I—Properties of Multi-Flex Aircraft Ducts in Sizes from 1 to 12 inches

Style (see notes)	Weight, lb. per ft. per in. of inside diameter		Max. service temperature, deg. F.	Max. internal pressure, lb. per sq. in.			Center line min. bend radius
	Corrugated section	Rigid section		1-in.	6-in.	12-in.	
1-A	0.15		350	15		5	1 dia.
1-AS	0.15		350	10		3	1 dia.
1-B	0.10		350	15		5	1 dia.
1-BS	0.09		350	10		3	1 dia.
1-CS	0.19		500	20		10	1 dia.
1-DS	0.07		500	5	3		¾ dia.
2-A	0.15	0.15	350	15		5	1 dia.
2-AS	0.15	0.15	350	10		3	1 dia.
2-B	0.10	0.10	350	15		5	1 dia.
2-BS	0.09	0.10	350	10		3	1 dia.
3-BS	0.09	0.06	350	10		5	1 dia.
3-CS	0.19	0.11	500	20		10	1 dia.
3-DS	0.07	0.03	500	5	3		¾ dia.
4-B		0.06	350	10		5	rigid
4-C		0.11	500	20		10	rigid
4-D		0.03	500	5	3		rigid
5		0.06	500	30		10	rigid

A = single ply of asbestos fabric, Underwriters' grade
B = single ply of medium-weight glass fabric
C = two plies of medium-weight glass fabric
D = two plies of light-weight glass fabric
S = soft finish

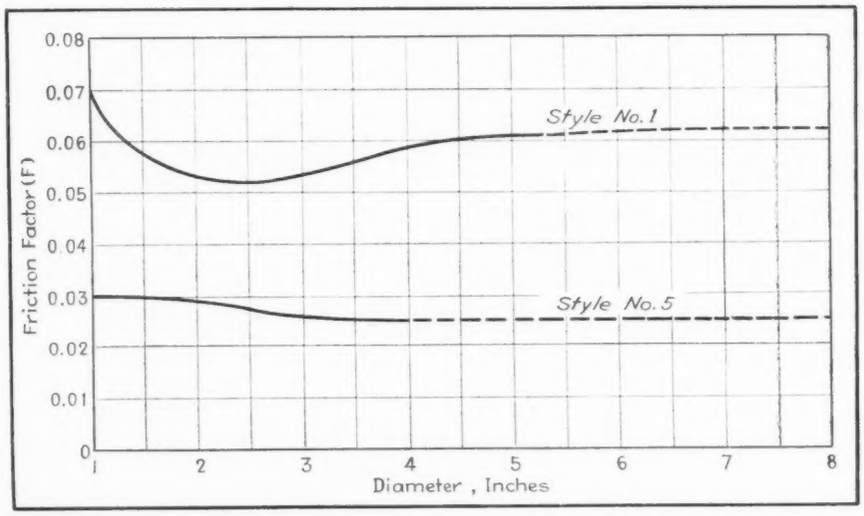


Fig. 4—Friction flow factors for straight sections of two styles of Multi-Flex ducts.

Fig. 3—Multi-Flex ducts can be used for U bends and for turns of smaller angles.

Composite Dimensioning Speeds Production and Inspection

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Methods of using composite dimensions to specify working tolerances that will result in satisfactory interchangeable manufactured parts and that facilitate inspection. Methods for defining dimensional limits of round holes, round corners and angular tolerances are also discussed as a corollary of correct drafting practice.

GOOD dimensioning is a requisite of good production designing. Drawing arrangement, choice of views, accuracy, neatness and speed are important factors in the preparation of a drawing; but nothing in drafting is more indicative of true engineering ability than the dimensioning method used.

Dimensions describe the final physical shape of a part, and are usually the controlling influences on manufacturing and inspection. If a given production drawing shows a reasonably accurate picture, and all elements of the design are shown in proper relationship, then all requirements for drafting accuracy are satisfied and further effort directed at increased accuracy is wasted. The object depicted by the drawing will be made in accordance with the dimensional limits given on the drawing, regardless of drafting accuracy. Also, limits such as 2.5005 in. max., 2.5000 in. min. are refined beyond the practical range of pictorial representation.

The assignment of working tolerances to individual linear dimensions that define a required area often results in inefficient production.

Areas that are to be checked by "go and no-go" inspection methods are best dimensioned by defining the minimum and maximum allowable limit areas. This is accepted practice in connection with round holes and shafts because it is easy to describe these by what appears to be a single dimension; the diameter. The diameter is deceptively simple, for it is not a linear but an areal dimension. With tolerances, the diameter defines the acceptable minimum and maximum circular areas.

A hole diameter can be specified on a drawing by using a single dimension with plus and minus tolerances as shown in Fig. 1(*A*). The two plug gages used for inspection of the product are shown Fig. 1(*B*) and (*C*), neglecting, for the sake of simplicity, gage manufacturing tolerances and gage wear allowances. If the "go" gage enters readily, the hole is larger than 1.000 in. dia., and one dimensional limit has been met. If the "no-go" gage does not enter readily, the hole is smaller than a 1.001 in. dia., and the other dimensional limit has been met.

A "go" gage can check all elements simultaneously, but a "no-go" gage can check only one linear dimension; in this example, the maximum distance between any two opposite points on the surface of the hole. Because of this limitation of the "no-go" gage, it must be tried in all possible positions. "No-go" plug gages are also commonly made full-round, but these will not check out-of-round holes properly. An out-of-round hole needs to be smaller than the full-round "no-go" gage in only one place to prevent entry of the gage. In this example, a full-round "no-go" gage would allow the product to pass inspection with an elongated hole, 1.0005 in. wide and 1.0020 in. long.

The optical comparator is well suited to "go and no-go" inspection of areas. By this device, an enlarged shadow of a suitable part can be super-imposed on a layout that is made to the scale of the enlargement. The main hindrance to more extensive use of the optical comparator is the lack of suitable dimensioning on drawings,

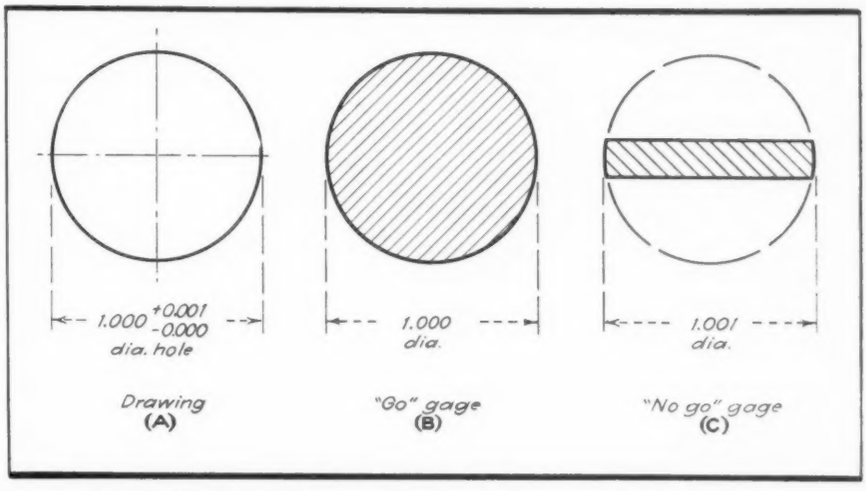

Fig. 1—The specification with plus and minus tolerances of a hole diameter on a drawing and dimensions of the two plug gages used for inspection of the product.

for if areas are disintegrated into linear elements each one must be separately measured for its dimensional limits.

A commonly used note on drawings, especially those of precisely machined parts, is "Break Corner 0.010-0.020 in." If a check for conformance is to be made by the optical comparator, the acceptance zone must first be defined. The extent of this zone is shown in Fig. 2, with examples of acceptable corners. This note is a good example of composite dimensioning and is accepted without question.

The following variation of the note is frequently found on drawings: "Break Corner 45 deg. x 0.015 in." This is a typical breakdown of an area into its component angular and linear dimensions, each requiring separate checking for tolerance. For this minor detail it is reasonable to assume that it is not required to have the angle checked separately for tolerance, but on many designs the engineer's intentions are not so easily defined and there is much loss in needless checking time and rejections. This type of dimensioning is properly used on drawings of parts where the angle is important.

Drawings specifying "Corner 0.010 — 0.020 in. R.," define the acceptance zone as shown in Fig. 3. It can be noted that a straight chamfer of suitable size will pass inspection, even though the designer had rounded corners in mind. Rounded corners can be assured by specifying closer limits. The acceptance zone is narrowed and everything excluded that is not substantially a radius. This leaves very little tolerance, as shown in Fig. 4, and is therefore an expensive method.

Rounded corners can also be assured by specifying allowable variations from a true radius that can vary in size within more generous limits. For example: "Corner 0.010 — 0.020 in. R., True Within 0.002 in." A series of concentric radii used for inspection is shown in Fig. 5, as well as an example of an acceptable corner.

It is apparent from this analysis that the first note, "Break Corner 0.010 — 0.020 in.," is the most desirable for production, as it permits the largest variation.

Failure to utilize the composite system of dimensioning for more com-

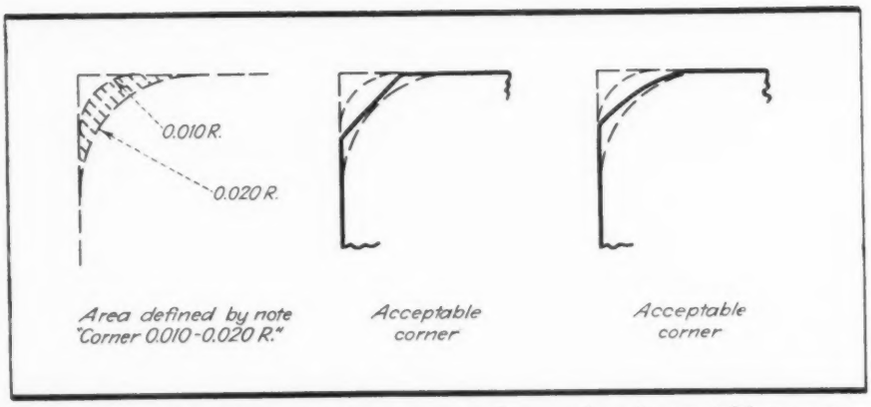

Fig. 2—The extent of an acceptance zone and examples of acceptable corners.

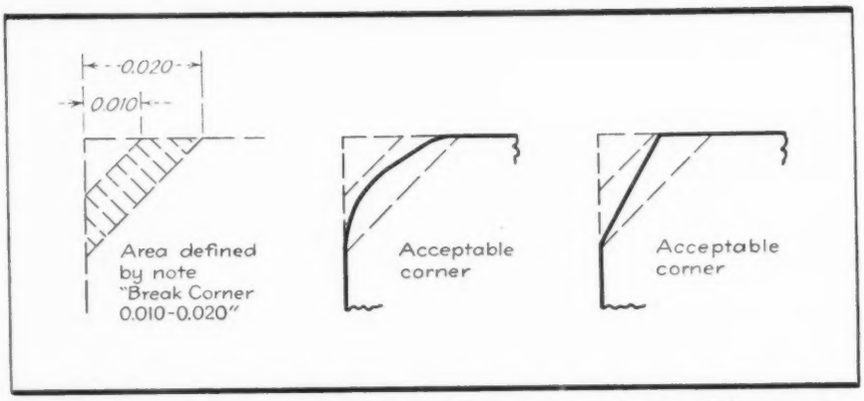

Fig. 3—Another case of extent of acceptance zone and acceptable corners.

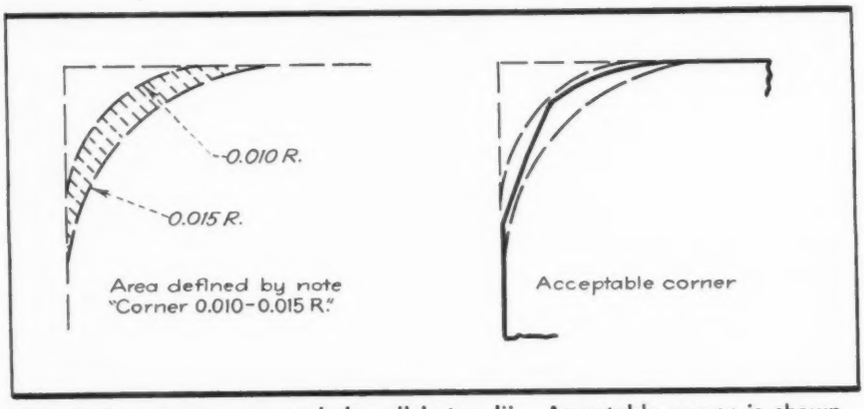

Fig. 4—Acceptance zone excludes all but radii. Acceptable corner is shown.

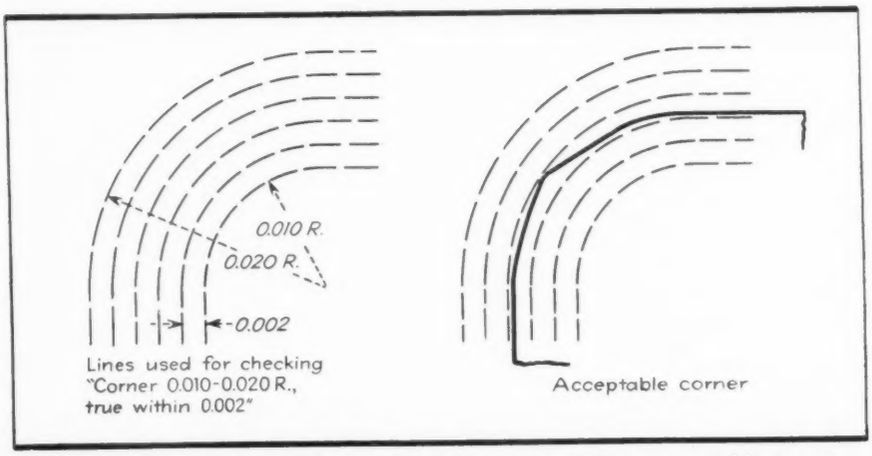

Fig. 5—A series of concentric radii for inspection and an acceptable corner.

plex geometric areas results in losses, especially in the manufacture of interchangeable components. This can be verified by observing the effects on a relatively simple non-circular area. It can be seen that the advantages of composite dimensioning increase with the geometrical complexity of the form.

A 12-point wrench-shaped hole, such as might be punched or broached in an adjusting nut retainer, is shown in Fig. 6. As indicated by the drawing note, there is a dimensional tolerance zone defined by the dimensions and angles given, but there is no tolerance on the angles used to define the two limits of this zone. Angular, as well as linear manufacturing tolerances, can be any amount within the confines of the zone. The advantages are apparent:

1. The assignment of the maximum allowable tolerance individually to angular and linear measurements is avoided. This is a time-consuming job, as angular tolerances not only reduce the amount of tolerance available for adjacent dimensions, but are cumulative as well.

2. The most efficient outline of punch or broach, allowing for maximum tool wear, can be determined without reconstructing the component angular and linear dimensional limits to find the maximum extent of the tolerance zone.

3. A larger percentage of acceptable parts is produced. The relatively close tolerances of component angular and linear dimensions cause rejections of many usable parts because it is impractical to state on a drawing that certain dimensional tolerances can be exceeded providing certain others are not fully absorbed.

4. Inspection can be accomplished without reconstruction of component angular and linear dimensional limits to find the maximum extent of the tolerance zone. Many angular measurements can also be eliminated as the only requirement is that the surface of the hole must be within an easily defined area.

Hole serrations can be dimensioned as shown in Fig. 7. The assurance of interchangeability is to be noted in this example, a highly desirable feature lacking in the commonly accepted standard. Variation in tooth spacing can occur only within the predetermined tolerance zone and parts will mate in any one of 36 positions.

The standardization of more complex shapes, such as gears and splines, is retarded by the prevalent opinion that each linear and angular dimension should be assigned its own tolerances. Under this system, a satisfactory standard would require microscopic manufacturing tolerances because of their cumulative effect. Rather than make this requirement necessary, a tolerance zone should be established, as was done in the standardization of screw-threads.

The evasiveness of orthodox dimension methods is apparent in many of the nationally accepted standards. For example, screw-thread specifications provide extra-generous pitch diameter tolerances for extra-long engagements to allow for more cumulative lead error. Lead error is objectionable because it can be a source of interference between mating parts. This interference can be detected through the use of "go" gages; the only requirement is that the threaded portion of the "go" gage must be at least as long as the intended engagement. Therefore, a more direct approach would be to specify the minimum threaded length of the "go" gage in standardized units. Although the prevention of thread lead error is a function of volumetric dimensioning, the standards attempt to control volume by areal dimensioning. This results in possible acceptance of a completely unusable product.

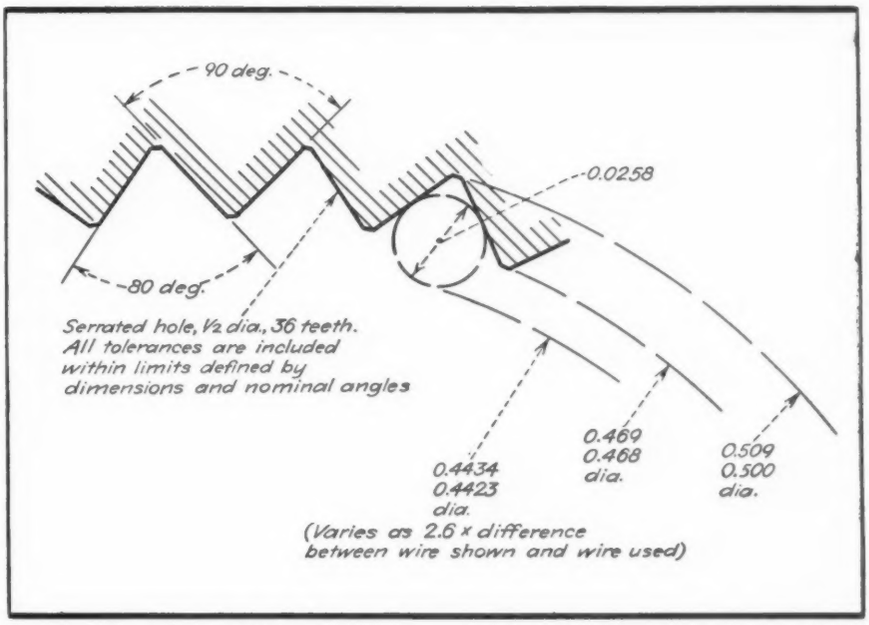

Fig. 7—One method of dimensioning a serrated hole to assure interchangeability.

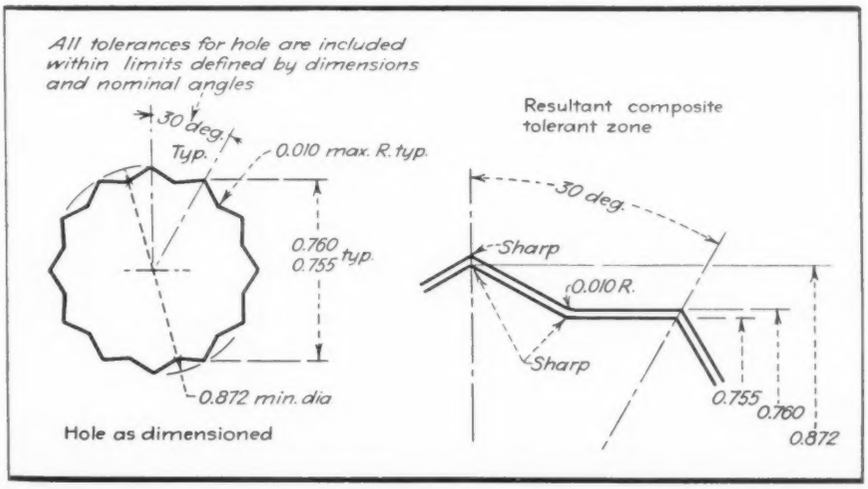

Fig. 6—A 12-point wrench-shaped hole such as might be punched in a nut retainer.

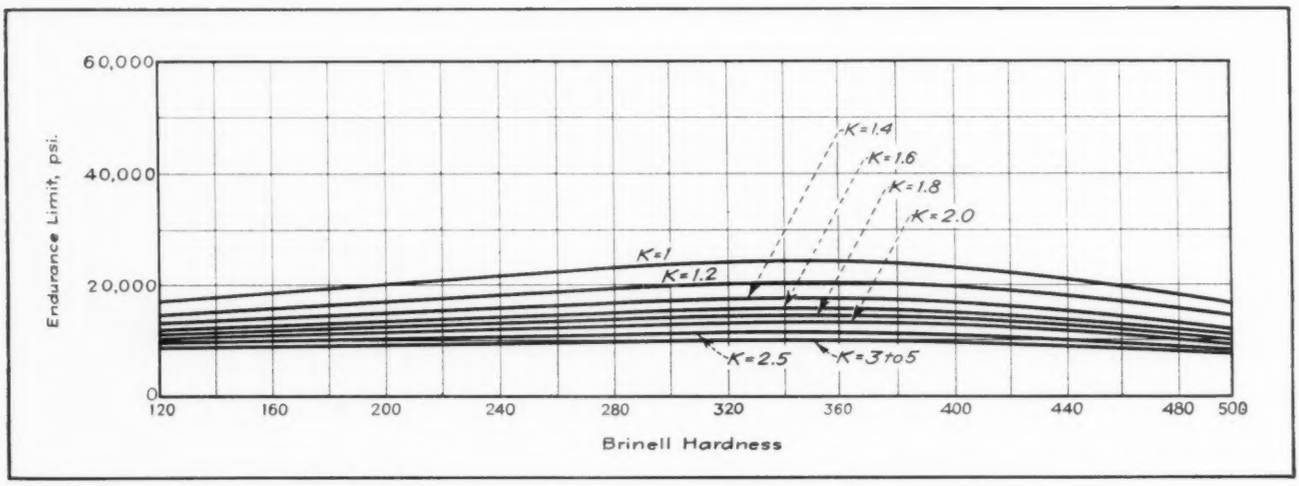

Fig. 1—Endurance limits for steel parts having as-forged surfaces.

Fatigue Strength of Steel Parts

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Editor's Note: In the article "Allowable Working Stresses for Steels" by C. Lipson and G. Noll that appeared in the March 1946 number of Product Engineering, charts were presented that related hardness, surface finish and conditions of loading with the fatigue strength of steel parts ranging from 160 to 555 Brinell hardness. In this article the authors extend that data to include the effect of stress concentration on the fatigue strength of steel parts.

WHEN service loads are static the problem of designing a steel part for strength is relatively simple: Strength is principally a function of hardness and section size; and the effect of surface finish and of stress concentration is of minor importance. To increase strength, therefore, it is sufficient to increase the properties of the section or to increase the hardness of the material.

With dynamic loading the design problem is more difficult. Those factors that are of no importance when loads are static play a major role when the loads are fluctuating. When designing a steel part for strength in fatigue, therefore, knowledge of the principal variables that affect fatigue strength is of primary importance.

The effects of these varables on the strength of parts have been studied by many investigators. There are available in literature (see References 1, 2, 3 and 4) several summaries relating hardness, conditions of loading and surface finish with fatigue strength. But few attempts have been made to incorporate in design data the effect of stress concentration on fatigue strength.

Graphs relating the endurance limit of steel parts with hardness, surface finish and stress concentration are presented in Figs. 1, 2, 3 and 4. Each graph refers to a specific class of surface finish: Fig. 1 to as-forged parts, Fig. 2 to ground parts, Fig. 3 to machined parts, and Fig. 4 to hot-rolled parts. See Reference 4 for a discussion of the validity of this classification of surface finish for manufactured parts.

In each graph is shown the endurance limit of steel parts of different Brinell hardness and different degrees of stress concentration factors K. The curves given by K equal to 1 correspond to the condition of no stress concentration; they were obtained from the available fatigue test data of specimens without any notch.

The curves for higher values of stress concentration for K ranging from 1.2 to 5 were obtained by dividing fatigue stress concentration factors K_f into the endurance limit values as given by the curves K equal to 1 for specimens without notches.

In selecting the values of K_f it was necessary to consider the effect of notch sensitivity of the material. R. E. Peterson has shown in "Stress-Concentration Phenomena in Fatigue of Metals," A.S.M.E. *Transactions*, APM 55-19, 1933, that the stress concentration factor in fatigue K_f can be defined in terms of notch sensitivity q and the geometrical stress concentration K by the expression

$$K_f = 1 + q(K - 1)$$

In Fig. 5 this relation is plotted for a range of usable values and is derived from test data available in literature. The lower limit of the band cor-

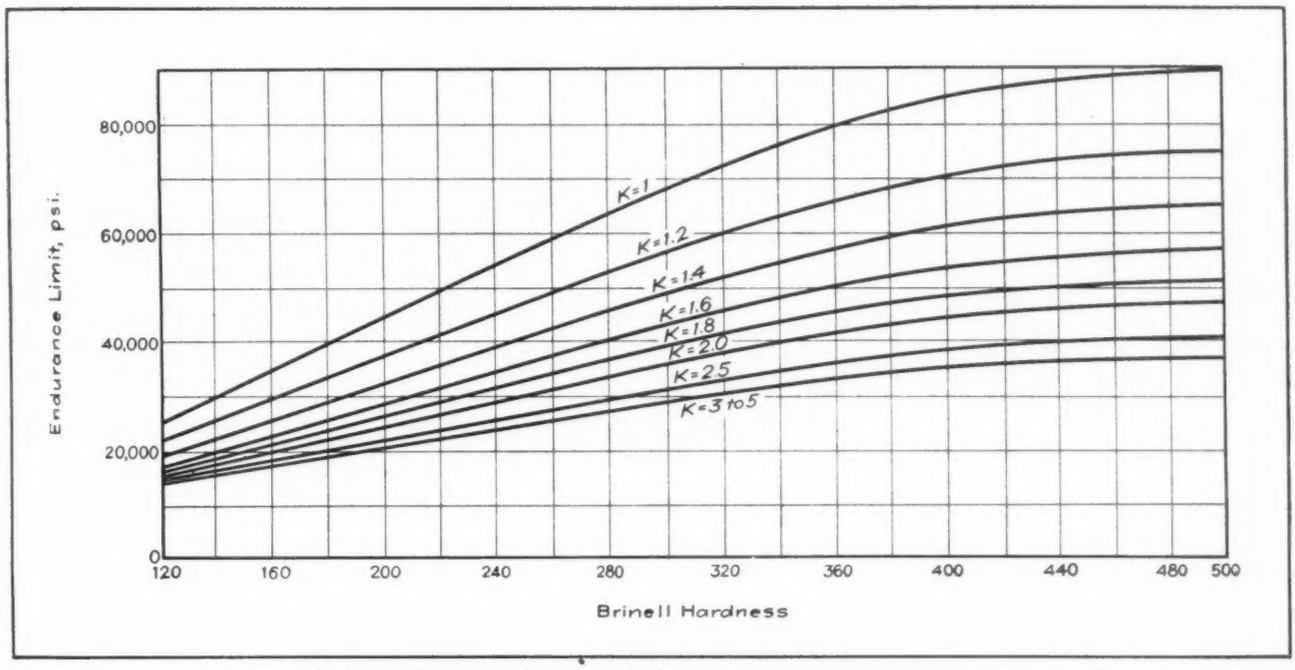

Fig. 2—Endurance limits for steel parts having ground surfaces.

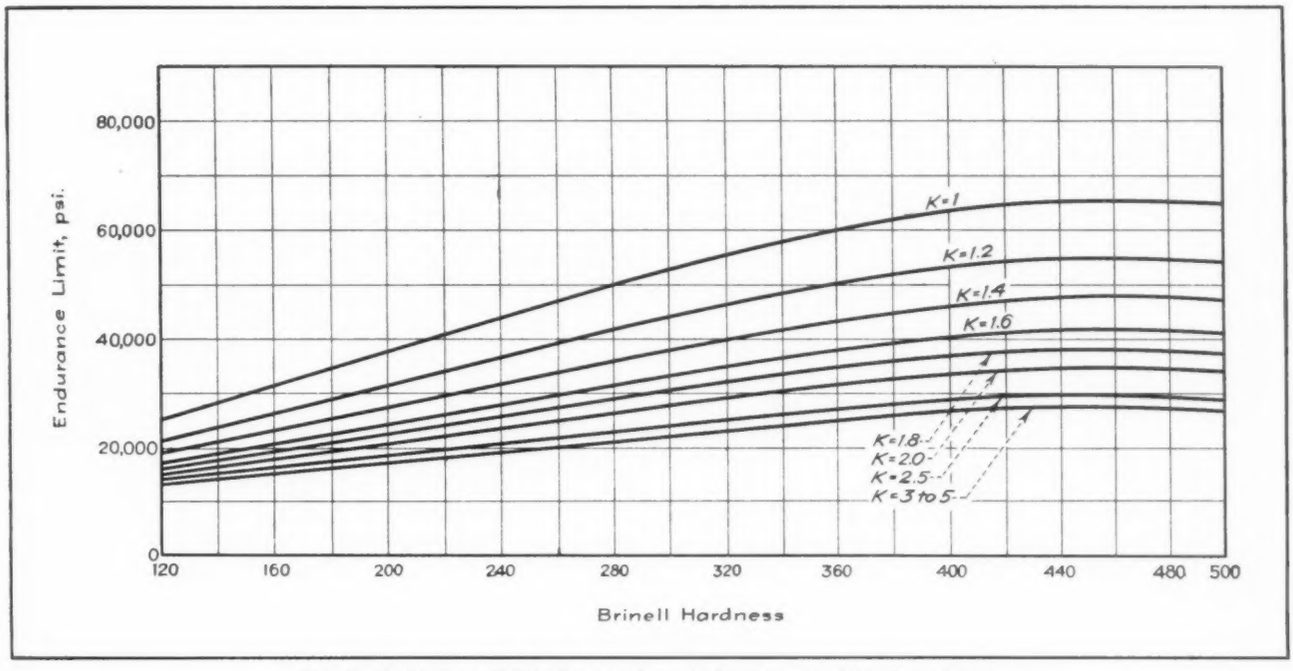

Fig. 3—Endurance limits for steel parts having machined surfaces.

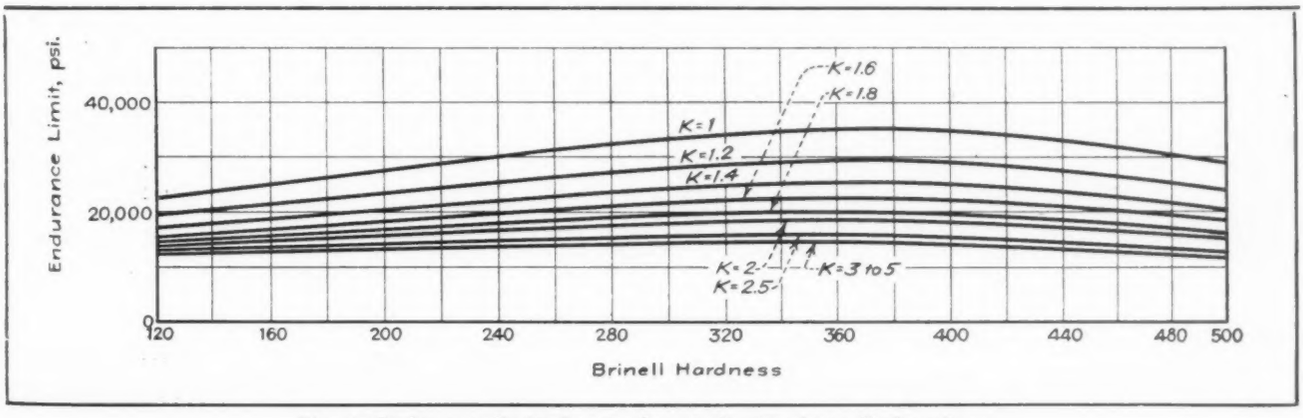

Fig. 4—Endurance limits for steel parts having hot-rolled surfaces.

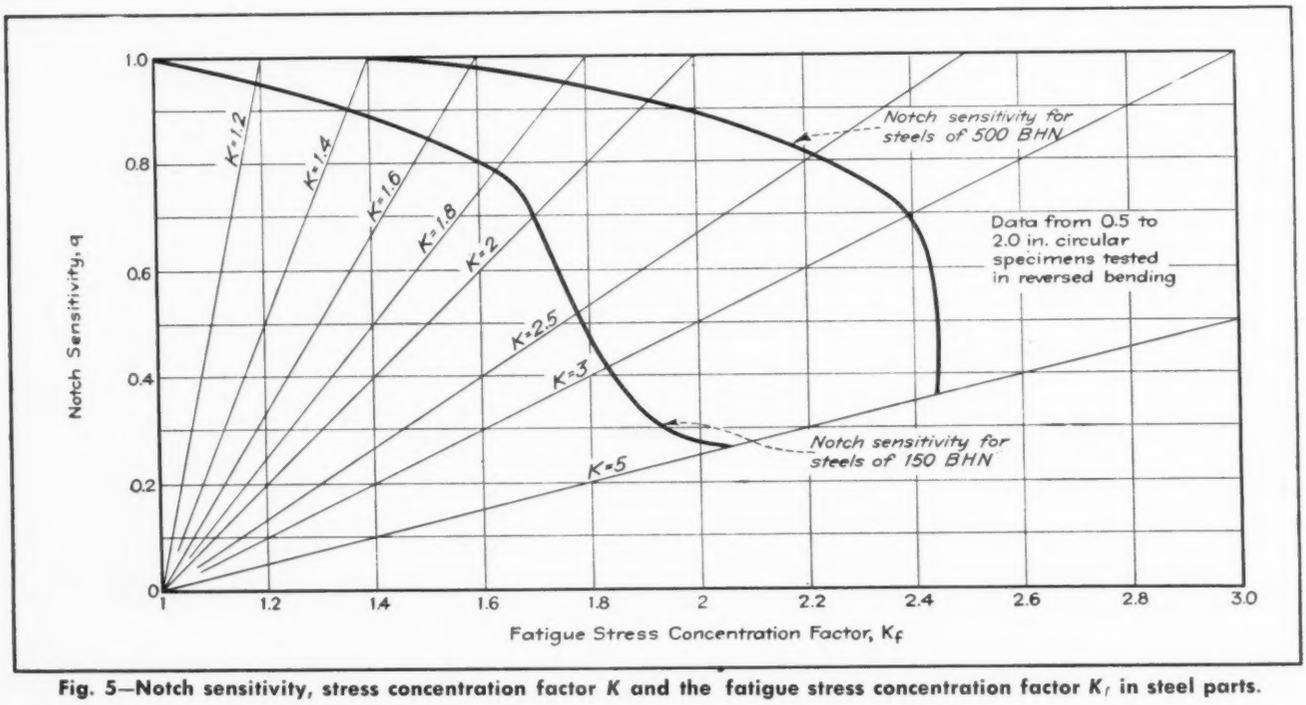

Fig. 5—Notch sensitivity, stress concentration factor *K* and the fatigue stress concentration factor K_f in steel parts.

responds to steels of 150 BHN and the upper limit to those of 500 BHN. The value of q equal to 0 implies lack of notch sensitivity and that of q equal to 1 implies the full effect. Cast iron has a very low notch sensitivity, which implies that this material is very little affected by the presence of notches, such as threads and keyways. As to steel members, annealed steels have a lower notch sensitivity than heat-treated steels.

It should be noted that the data contained in Fig. 5 are supplementary information included to explain the method of obtaining data used in plotting Figs. 1, 2, 3 and 4. That is, K_f was determined from the known values of q and K and used to establish Figs. 1, 2, 3 and 4. Thus, when the Brinell hardness, surface condition and stress concentration factor of a steel part are known, its endurance limit can be determined directly from Figs. 1, 2, 3 or 4. A machined steel part of 360 Brinell and having a stress concentration factor K equal to 1.6 is shown by Fig. 3 to have an endurance limit of 38,000 pounds per sq. inch.

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German Absorption-Type Refrigerator

AN ABSORPTION-TYPE REFRIGERATOR for household use was developed in Germany just before the war, according to a report by the Office of Technical Services, Department of Commerce. About 400 units were built and were giving satisfactory service.

The domestic absorption-type refrigerator uses solid calcium chloride as the absorbent, ammonia as the refrigerant, and stove gas as the heater fuel. Its operation is automatic, eliminating the need for a time switch to control the heating and absorption periods. The standard model had a capacity of 60 liters—somewhat more than 2 cu ft—and sold for 350 marks (about $82) in 1939.

The principal parts of the refrigerating system consist of a liquid receiver embedded in the insulation in the top of the refrigerator cabinet, an evaporator suspended from the ceiling of the cabinet's interior, and a generator-absorber and a finned condenser mounted in the rear panel of the cabinet. The generator-absorber is made of steel pressings welded together to form vertical cylindrical channels. The channels hold small copper cups containing calcium chloride. Liquid ammonia from the liquid receiver changes into gas in the evaporator by absorbing heat from the food stored in the cabinet. The gaseous ammonia flows by way of the receiver to the generator-absorber where the calcium chloride absorbs it, condensing it into a liquid. A metallic bellows operated by a thermostat drives off the heat.

When the generator-absorber becomes sufficiently saturated with liquid ammonia, a bi-metal valve increases the amount of stove gas fed to a pilot light. The heat vaporizes the liquid ammonia and forces the vapor into the finned condenser where it cools and once again turns into a liquid which then returns to the liquid receiver.

According to the report, the following test results were typical of the refrigerator's operations:

Room temp.	25 C
Cabinet air	3 to 6 deg. C
Evaporator	8 to 9 deg. C
Equivalent food load	4.78 watts
Heating time	1 h, 45 min
Gas consumption	472.5 liters (about 20,000 Btu)
"Off" period	8 hr

TECHNICAL NEWS HIGHLIGHTS

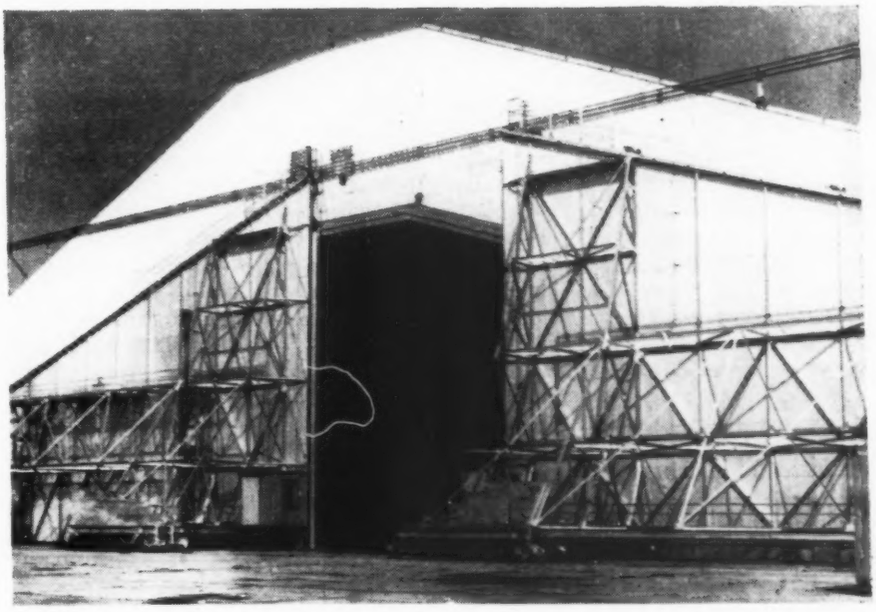
Climatic Hangar For All-Weather Testing

YEAR-ROUND TESTING of aircraft and aircraft equipment under controlled temperatures and other climatic conditions is now possible in the new climatic hangar constructed at the Air Proving Ground Command, Eglin Field, Florida. The Army Air Forces has already begun using the 8 million dollar structure to test planes and equipment in extremes of cold, heat, rain, snow, sand and wind.

The Army Air Forces now is able to make initial tests of new aircraft, required to perform satisfactorily from −65 to +165 F., under controlled weather conditions instead of taking them to bases in tropical regions or in the Arctic, such as Ladd Field, Alaska. This is expected to save many months in the early phases of type testing, but experiments with groups of planes or personnel must still be made in the field.

Described as the world largest cold-weather testing laboratory, the main unit will accommodate the B-36, the global bomber with a 230-foot wing span. The climatic hangar project consists mainly of an insulated hangar 200 by 250 feet, and 70 ft. high; an equipment and engine test room 30 by 133 ft., and 25 feet high; a cold test room, hot test room, desert test room, jungle test room, and tropic-marine test room, each 13 by 13 ft.; an all weather room for physiological testing, 13 by 34 ft.; and a refrigerated strato-chamber.

Temperatures within the hangar and test rooms can be maintained from −70 F to +165 F. Relative humidities can be maintained from 10 to 95 percent or 1.5 in. mercury vapor pressure, whichever is lower when temperatures are maintained in the range of +50 F to +165 F. There is no provision for controlling relative humidities at temperatures lower than + 50 F. Provisions have been made for localized wind storms up to 100 m.p.h. in combination with sleet, snow, rain, dust, and sand. Artificial sunlight equivalent to noonday desert sun is provided. Thus, all normal and extreme climatic conditions can be simulated within the hangar or test rooms. There are no provisions for operating the hangar under reduced pressures; however, a refrigerated variable pressure chamber (strato-chamber) is provided for high altitude and climb testing.



Front view of the climatic hangar, showing main door, one of seven variously-sized doors, at Air Proving Ground Command Headquarters, Eglin Field, Fla.

The great size of the hangar makes it possible to subject the largest military airplane now designed and under construction to climatic functional testing. All types of aircraft, including jet engined and prop-jet aircraft and their parts, can be tested. Engines can be run up and ground tested, weapons fired, bombs dropped, simulated landings and takeoffs made to test landing gear struts, brake action checked, and the functioning of electrical, hydraulic and heating systems tested. Motorized ground vehicles can be driven within the hangar and subjected to simulated road tests. Ground equipment can be subjected to climatic tests to determine its suitability. The physiological testing facilities are such that personnel and personal equipment can be tested in all climatic conditions, at all operating altitudes, and under flight-climb conditions. Also, test facilities are provided so that climatic tests of long duration can be made to determine weathering effects on both stored material and operating equipment.

In planning the Climatic Hangar Project, the objective has been to provide facilities which will simulate service conditions. Climatic testing in the hangar can be closely coordinated with service testing at natural climatic locations. No attempt has been made to provide facilities suitable only for experimental and developmental testing as this is the responsibility of other AAF agencies.

Principal uses of the hangar have been classified as follows:

1. Functional operational testing of completely assembled aircraft. This will

cover all systems, integral assemblies and parts, including engine starts and ground run-ups with engines installed in the airplanes.

2. Testing of all ground equipment used in the operation and maintenance of aircraft.

3. Testing f motorized ground vehicles including operating testing on a road testing course.

4. Testing of personal clothing and equipment for determination of the types which give maximum efficiency in performing maintenance work on aircraft.

5. Study of the effects of extreme weather conditions on personnel.

6. Study of the time required to perform maintenance work under different extreme weather conditions.

The hangar has a clear working space 250 ft. wide and 200 ft. long. The height is 25 ft. at the sides, increasing to 60 ft. at the center. The total volume inclosed is approximately 2,900,000 cu.ft. Cooling and heating are provided by air circulation through ducts from eight plenum chambers located in the adjoining south lean-to. A refrigeration system with freon centrifugal compressors supplies cooling. A steam heating plant with steam coils provides the heating.

The main hangar door which closes the open side of the hangar is self-supporting and self-propelled. It is built in two sections, each weighing 200 tons. The trucks supporting the sections run on pairs of rails 25 feet apart. When the sections move into place to close the hangar, hooks on the sections engage in catches about the perimeter of the opening. A power drive draws up on the hooks and the sections move toward the hangar approximately 6 inches sealing sponge rubber gaskets to form a tight seal around the opening. Also, a cam forces rubber pads at the bottom of the door into contact with the hangar floor. The main door can be opened in seven minutes. A vertical lift door 50 ft. wide and 15 ft. high is located in the north half of the main door. This door is counter weighted and electrically operated. An entrance lock is being designed for this door so that small aircraft and other equipment can pass through this opening without loss of hangar air. The 50-ft. door can be opened in 2 minutes. The entire door is insulated with 13 in. of glass wool board inclosed on both sides with welded steel vapor barriers.

Within the hangar are three principal test centers. These are above the test service rooms, and are connected to them by access openings. The east test center is especially designed for testing of engines on complete aircraft. Two semi-flexible exhaust ducts for reciprocating engines and one for jet engines are located in this area. Radiating from the three test service rooms to distributed points within the hangar are empty conduits. These conduits will accommodate the services for tests to be conducted at points in the hangar other than at the main test centers. Also, two additional reciprocating engine exhaust ducts are provided beneath the floor of the hangar so that aircraft engines can be tested at other points than at the east test center. The east test center is located adjacent to the fixed bomb pit. The mobile observation rooms will facilitate testing at points other than the main test centers. A small instrument connection panel is installed at each of the three test centers. These supplement the panels in the test service rooms, and in the signal systems.

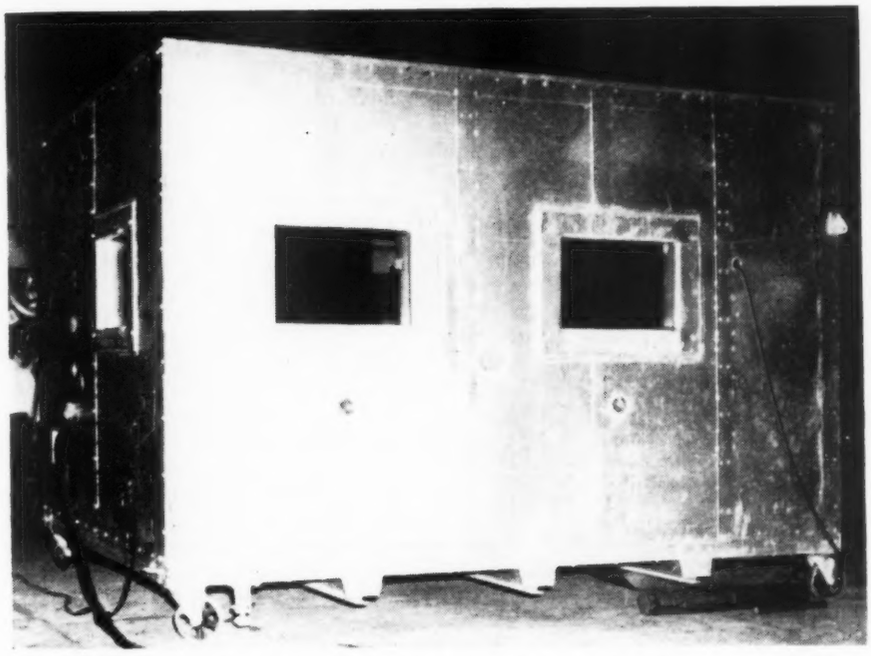
Instruments behind the camerman indicate the temperature at —40 deg. F. A winterization process of cameras and equipment is necessary for operation in extemely low temperatures.

Air Proving Ground Command Photos

Special Test Equipment

A landing gear actuator is under construction for the testing of the landing gear of aircraft in a manner simulating landing and take-off. This actuator is a hydraulic operated mechanism which is placed under one wheel of the landing gear of an aircraft. The unit has a capacity of 20,000 lb. and thus is suitable for testing aircraft weighing up to 40,000 lbs. The apparatus is capable of actuating the 20,000 lb. landing gear load at a frequency from 28½ cycles per minute at a 12 in. stroke to 114 cycles per min. at a 3 in. stroke. Controls are provided so that the length of the stroke, the frequency of the stroke, and the position of the mid-point of the stroke can be varied instantaneously and simultaneously by the operator while the machine is in operation. The apparatus is designed for operation in a temperature range from —70 to +165 F. It is mobile on retracting casters and the height of the landing gear tire cradle, when the apparatus is in operating position, is 24 inches above the floor. The apparatus is actuated by two 20 explosion proof electric motors. Safety provisions to prevent overloading have been incorporated into the apparatus. The landing gear actuator can be used for testing the landing gear of aircraft weighing more than 40,000 lb. by partially supporting the aircraft weight by jacks to simulate the airborne condition of landing.

The all-weather room consists of a main chamber approximately 34 by 13 ft., by 11 ft. high, and an ante-room or entrance lock approximately 15 by 9½ ft. by 10 ft. high. The main chamber is insulated with corkboard 12 in. thick, covered with a stainless steel in-



This portable observatory, insulated to withstand the —70 F low temperature range of the climatic hangar, offers test personnel a close range view of experiments.

terior liner. Large non-frosting observation windows are provided for viewing testing from the outside.

Temperatures can be reduced in the main chamber from +70 to —40 F in six hours, and to —70 F in twenty-four hours. Temperatures can also be raised from +70 to +170 F in two hours. The maximum relative humidities possible in the main chamber vary from 95% at 65 F dry bulb to 45% at +165 F dry bulb. The minimum relative humidity is 5%. No provisions have been made for reducing the pressure within the room.

A rain and mist making apparatus is provided for simulating rainstorms from ½ to 15 inches per hour. Also, there is a built-in wind machine capable of air velocities of from 5 to 35 miles per hour. The room can be partially filled with water for the testing of life rafts, immersion suits, and similar equipment for protection of personnel.

The strato-chamber consists of a main climb chamber and entrance lock, constructed of welded steel insulated with 13 sheets of a reflective metal insulation in the main chamber and of 7 sheets in the lock. The chamber is constructed to withstand pressures from zero absolute to one atmosphere. Chamber size is 9½ by 13½ ft., by 12 ft. high, lock size 10 by 4½ ft. by 12 ft. high. Temperatures can be reduced from +70 to —70 F in 12 minutes after an initial pre-cooling of the chamber to —70 F and reheating to +70 F prior to test run, with 10 men in heated suits in the climb chamber. Temperatures can be further reduced to approximately —94 F with 2 men in heated suits in the chamber.

German Ignition Developments Described

COMPACT MAGNETOS for sparking and lighting motorcycles, and experiments with various types of ignition systems for automotive engines are among German ignition developments described in seven reports of the Office of Technical Services, Department of Commerce.

Four of the reports describe ignition developments of the Robert Bosch Company, including flywheel magnetos, high frequency ignition, electronic ignition and low tension spark plugs. The reports were prepared by OTS investigator Alfred J. Poole, liaison engineer of the Scintilla Magneto Division, Bendix Aviation Corp., Sidney, N. Y. The fifth report covers low-tension ignition developed for the Junkers Company. The sixth and the seventh describe chemical ignition methods.

Bosch flywheel magnetos for German motorcycles have been so highly developed that they are probably superior to anything of the kind, regardless of place of manufacture, according to Mr. Poole. Coils for producing lighting current in the flywheel magneto systems have also received particular attention. Both lighting and ignition have been consolidated into units that are simple, compact, and reliable.

Advantages sought in the high-frequency ignition work conducted by the Bosch Company were longer sparks, reduced fouling, lowered danger of shock from the electrical system, and increased serviceable life of spark plugs. Several combinations of condensers and transformers were tried but no great claims were made for the systems developed, according to the investigator. Disadvantages of high frequency compared with standard ignition include heavy corrosion of the distributor electrodes, greater cost, and the necessity of installing shielding to prevent radio interference.

"Regardless of the advantage of high-frequency ignition," Mr. Poole comments, "its use as a substitute for standard ignition cannot be considered owing to its short operating time and high cost."

Electronic ignition experiments by Bosch were undertaken, according to the fourth report on the Bosch Company, in an effort to obtain such advantages as improved accuracy in spark timing, saving of space and weight, freedom from wearing parts, satisfactory operation at high altitudes, and conservation of scarce platinum, cobalt, and nickel. The control system was activated by lamps which cast a beam of light through a perforated disk on photocells. Although hot sparks at the rate of 30,000 per minute were said to have been obtained, disadvantages such as slow starting because of the time required for tubes to heat up were reported. Considerable research and development will be needed to perfect such a system.

Because airplane engines operating at high altitude (about 7 miles) may develop ignition trouble due to the tendency of current to jump the insulation of spark plugs or because insulation may deteriorate, the Bosch Company experimented with low-voltage ignition systems of from 400 up to 2,500 volts to replace systems of the order of 10,000 volts. Although some success was obtained, efforts to develop a spark plug for low tension ignition did not reach the manufacturing stage.

In the low tension development work, mica insulation was tried as a way to

guide the spark between the electrodes. However, after short periods of operation the current burrowed through the mica instead of igniting the charge. An insert of special glass between the electrodes gave better results, but spark failure occurred after operation of from 2,400 to 3,600 miles. A ceramic tube fused in the plug gave even better performance. The war was over, however, before deevlopment was completed. The investigator states that although the tests were too short to be conclusive the ceramic tube development appears to have possibilities.

Another low-voltage ignition system, developed by the Junkers plant at Dessau in cooperation with the firms of Siemens and Beru, is described in a report prepared by Major J. R. Parry of the British Ministry of Supply and C. A. Lindblom of the U. S. Ordnance Department for the Combined Intelligence Objectives Sub-Committee. The Junkers system, which operates between 400 and 1,000 volts, uses a spark plug in which the sparks glide along ignition electrodes instead of jumping a gap.

The Junkers-Siemens-Beru low-tension ignition, according to the investigators, "was brought to a reasonable state of reliability and with more development work could have reached the same degree of reliability as high tension ignition in about a year."

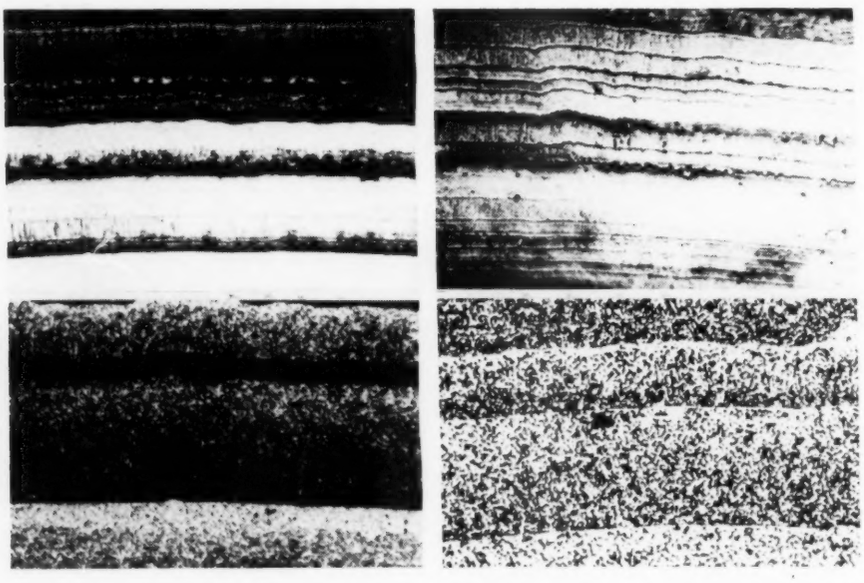
Chemical ignition is the subject of a report by Lieutenant R. J. Bender of the U. S. Naval Technical Mission in Europe. In this so-called "Ring" process, a liquid ether sprayed into the combustion chamber is ignited by the heat of compression and the resulting ether flame ignites the fuel. The method operates over the entire range of fuel-air mixtures and reduces knocking. However, it is expensive and requires auxiliary starting spark plugs.

"Ignition Oil," a chemical ignition substance developed by I. G. Farbenindustrie and tested at the Junkers plant in Dessau, is described in an additional report by Maj. Parry and Mr. Lindblom. Results in a single cylinder engine indicated about the same output as with spark ignition but with "thermal sensitivity" causing uncertain firing or failure to start when the engine was cold. The tests were preliminary only, and showed the need for additional chemical and mechanical developments.

Electroless Plating on Metals by Chemical Reduction

A NEW METHOD FOR PLATING NICKEL and cobalt on metal surfaces without the use of electric current has been developed by the National Bureau of Standards. This process, known as electroless plating, is brought about by chemical reduction of a nickel or cobalt salt with hypophosphite in hot solution. The reaction is catalytic, and under prescribed conditions of concentration and acidity, no plating occurs unless certain metals, such as steel or nickel, are introduced in the bath. The reduction then occurs only on the surface of the immersed metal, with the production of an adherent coating of 93 to 97 percent purity.

Photomicrographs of deposits obtained in this way show both a laminar and a columnar structure, similar to bright nickel electrodeposits. The electroless deposits are of good quality—sound though brittle, and usually bright. Since they can be made as hard as tool steel, the method may prove useful where hard, wear-resistant surfaces are required, as in bearings. The process is particularly applicable to the plating of recesses, irregular-shaped objects, and enclosed areas such as tubes.



"Electroless" nickel deposits from acid solution. Upper left, laminations and columnar structure; hardness 500 (Knoop scale). Upper right, after annealing at 400 C. for 30 min., maximum hardness of 800. Lower left, after annealing at 600 deg. C. for 30 min., showing precipitation. Lower right, after annealing for 30 min. at 800 C., showing excessive precipitation; hardness 470.

The equipment is simple and more easily assembled than that required for electroplating. No generators, rheostats, special racks, or contacts are necessary. Small parts which cannot be barrel-plated economically are readily plated by the electroless process if suspended by a string or in a bag affording ample exposure of the metal surface to the solution. There is no need of constant motion, as in barrel plating, since current distribution is not involved.

Objects to be plated are cleaned by any of the accepted procedures and are given an acid dip before being suspended in the hot solution. The rate of deposition is about the same as in barrel electroplating, ranging from 0.0002 to 0.0008 inch per hour, depending upon the type of solution used. The composition of the plating bath may vary widely.

As formed, electroless nickel deposits are brittle but become ductile when heated. These deposits are harder than the ordinary electrodeposited nickel, and upon heating their hardness is still further increased. This is in contrast to the behavior of "hard" electrodeposited nickel, which has high initial hardness but softens upon heating. The hardening is "precipitation hardening."

Nickel deposits on mild steel cannot be flaked off by bending, but on high-carbon steel this property is less satisfactory. In salt-spray tests on steel coated with 0.0002, 0.0005, and 0.001 inch of electroless nickel, in comparison with similar panels coated with electrodeposited nickel, the protective value of the two types of coatings was virtually the same. However, the electroless cobalt does not compare so favorably with electrodeposited cobalt.

WASHINGTON NOTES

Administration Defines Its Research Policy

On the heels of its veto of the science foundation bill, the Truman administration has laid out its long-range program for scientific research with the publication of "Science and Public Policy", the report of the President's Scientific Research Board. The Board, a cabinet-level group headed by presidential assistant John Steelman, was appointed last October to review the whole field of government policy on science.

MONEY FOR RESEARCH—Public and private expenditures on research this year total more than 1 billion dollars. This is an all-time high, nearly twice the wartime average and about four times the pre-war level. More than half of the expenditure is federal, and about 500 million dollars military.

However, this amount, in the view of the board, fails to meet present military and economic needs. More or less arbitrarily, the board estimates that at least one percent of the national income should go for research—about twice the present level. The board would like to see expenditures on research in the pure science quadrupled to something like 440 million dollars; medical research stepped up to about 300 million dollars; military work held to its present level; and non-military applied research, industrial and governmental, increased to about a billion dollars.

Manpower, however, presents a difficulty. Present expenditures on research have created a shortage of experienced technicians—a shortage which particularly affects the teaching and pure research staffs of universities. Therefore, the board recommends no immediate increase in expenditure. This will come gradually—as the thousands of students now in college complete their training. It may be 1957 before the kind of science program the board wants can be in full operation.

Following are some of the board's recommendations:

1. Organization of a permanent interdepartmental committee on science to coordinate federal scientific programs. It would set general policies; prevent overlapping projects (there are not many according to the board, in civilian agencies, but military programs are full of them); maintain a sensible balance is kept between different fields of research. President Truman claims that this is an immediate objective.

2. Amendment of corporation tax laws to provide more incentive for expenditures on industrial research. This will probably come up when Congress reconsiders the tax laws next year.

3. Study by the Council of Economic Advisors of factors limiting research in specific industries—such as the Division of the building industry into small units and the railroads' heavy investment in obsolete equipment.

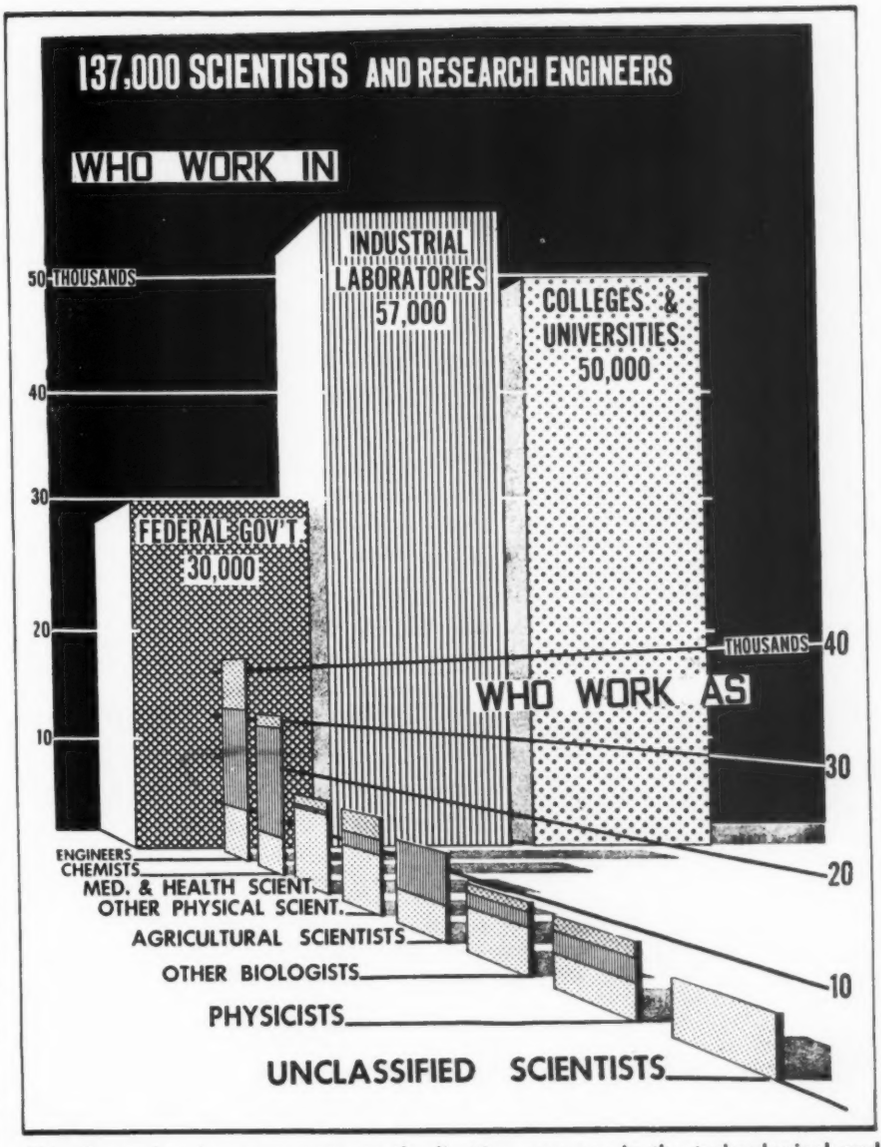
4. Creation by Congress of a National Science Foundation which would concentrate on financing fundamental research in universities. Unlike the bill vetoed this year it would have a director responsible to the President. It would spend about 50 million dollars the first year, and reach at least 250 million dollars by 1957.

5. Provision of scholarships for science students. This should be done before 1950, when present veterans' educational benefits will be running out. It would be administered by the U. S. Office of Education, rather than the Foundation. It would be part of a general program of federal aid to college students.

6. Legislation permitting use of outright grants instead of research contracts when the government finances non-federal research work.

7. Legislation permitting all departments to obligate research money five years in advance, to insure stable programs. Only the Office of Naval Research and the Atomic Energy Commission can do this at present.

8. Inclusion in the rehabilitation programs of the Marshall plan of a provision for re-establishing scientific research in Europe on a basis of free



This chart, showing manpower as the limiting resource in the technological and scientific progress of the United States, is taken from "Science and Public Policy", a special report of the Presidents' Scientific Research Board, issued recently.

international exchange of information.

9. Improved arrangements for translation and distribution of published Russian scientific results. Russia is now spending just about the same amount on science as the United States.

War Department Polls Utilization of Scientists

The War Department, in cooperation with scientific societies, is finding out what happened to the country's scientific talent during World War II. First results, announced last month, show that a high percentage of chemists and chemical engineers who entered the Army or Navy considered their specialized experience used only partly or not at all by the military services.

The first survey was conducted in conjunction with the American Chemical Society. Similar surveys are under way or planned by the Institute of Physics, Union of Biological Societies, the Geological Society of America, the American Association of Petroleum Geologists, the Association of Professional Geographers, the American Mathematical Society, the Engineers Joint Council, and the American Psychological Association. In all, the War Department expects to have 35 or 40 societies cooperate in polling their members.

When the polls of scientists, via questionnaires, are completed, the scientific societies themselves hope to have documentary evidence to support what they contended was needed during World War II: A special pool for technical and scientific men to be drawn upon and used to the fullest in their special fields or collateral fields.

The surveys are being carried out under the direction of Dr. David M. Delo, of the Scientific Manpower Branch of the Research and Development Division of the War Department General Staff.

The poll of the chemists and chemical engineers showed some interesting results.

Out of 31,000 replies to 48,000 questionnaires, 15 percent (4,506) had been in the armed forces. Of this group in service 78 percent were below 35 years of age, and almost half of them reported improper utilization. About one-fourth of the 35-and-over age group in uniform reported poor utilization of their capabilities. In all, about 40 percent of the chemists in service claimed they were utilized only part of the time, or not at all.

About 58 percent of all chemists and chemical engineers answering the poll reported that their principal war work was in industry; 8.5 percent said it was teaching; 17 percent said it was government-sponsored research or work for a government agency.

Of those who entered military service, the survey shows that in general the youngest technical men were most apt to be poorly utilized. As a group, those who maintained their Army reserve status got called into uniform quickly in their basic branch, and never transferred to work that might match their professional qualifications.

Infrared Aids Precision Casting

REPLACING STEAM TABLES, low temperature ovens, and hot plates, banks of 250-watt infrared lamps—248 in all—are used to dry the molds and melt out 98 percent of the wax pattern at the precision casting foundry of the Westinghouse Electric Corporation. The balance of the wax is burned out in the preheat furnace where molds are heated to 1000 C for casting. In making gas turbine blades and other intricate or hard-to-machine castings, the infrared process has been found to reduce mold cracking, avoiding defective castings.

Commodity Standard Division Set Up at Standards Bureau

A single Commodity Standards Division, which consolidates the Commercial Standards and Simplified Practice divisions of the National Bureau of Standards, has been announced by Dr. E. U. Condon, Director of the Bureau.

The new Commodity Standards Division will continue the Bureau's coordinating role in the development of voluntary simplified practice recommendations and commercial standards with industrial and technical groups. In addition, the division will be responsible for coordinating Bureau work for the Federal Specifications Board. Edwin W. Ely, former chief of the Simplified Practice Divisions has been appointed as chief of the division and F. W. Reynolds, former chief of Commercial Standards, as assistant chief.

The Bureau works in close cooperation with non-federal agencies doing similar work. At the present time the Bureau is represented on over 100 committees of the American Standards Association and is the managing agency for 17 American Standards Association projects. Similarly, the Bureau is represented on 55 of the 63 technical committees of the American Society for

Testing Materials, with more than 100 memberships. Close relations are maintained with other technical and industrial organizations.

An important addition to the division's functions will be the Federal Specifications work. Such specifications are vital in the purchase of goods by federal agencies because the bid system used by the government to ensure Federal economies in purchasing and to give an equal opportunity to all manufacturers, requires specifications for its operation. The division will also participate in the work of the Technical Committee of the United States Commodity Catalog Board which establishes standard lists of items for procurement and develops standard nomenclature and designation for goods purchased by the Federal Government.

Commissioner Ooms Resigns

Lawrence C. Kingsland, well known St. Louis patent attorney, has been named U. S. Patent Commissioner, succeeding Casper Ooms. While his appointment requires Congressional confirmation, there is no reason to believe that any opposition will develop.

Mr. Ooms, Commissioner of Patents since July 1945, is returning to private patent law practice. The agreement when he took office was that he would remain for at least a two-year period.

Mr. Kingsland, long a friend of President Truman, was picked by the Commerce Department last January to advise the legislature of the new Philippine Republic on drafting patent and trade mark laws. He is 63, a native of St. Louis, graduate of Washington University in that city, and has practiced law since 1908. Formerly he was a member of the Democratic Central Committee of St. Louis. In recent years, he has not been active in politics.

Foreign Reports

. . . . . from McGraw-Hill World News

Dutch Discover New Plastics

The laboratories of applied natural science at Delft (Holland) have found a new group of raw materials, so far not described in scientific literature, which are claimed to make cheaper the manufacture of plastics. The new product resembles methyl methacrylate. The announcement was made by Dr. L. C. Stoutjesdyk, manager of the Plastics Institute of Delft.

It is claimed that it will be possible to produce plastics with highly divergent properties. For instance, the surface hardness of plastics can be varied. Dr. Stoutjesdyk stated that existing Dutch industries would find no difficulty in switching to the production of these compounds.

Indian Standards Institution Functioning

The recently-formed Indian Standards Institution already has enrolled nearly 300 commercial and corporate bodies as members and has announced the form which its first activities will take. It is setting up a set of Indian Standard Marks, similar to British Standard Specifications, which will be granted only to producers who give satisfactory evidence of meeting and preserving quality requirements by strict control of production. The National Laboratories of the Council of Scientific and Industrial Research will aid in establishing the standards and checking on adherence.

Of the five fields to be covered—buildings, chemicals, agricultural and food products, engineering and textiles—only the latter two have been dealt with thus far. However, the ISI has affiliated with the International Organization for Standardization and has been assigned the task of setting up international standards for mica and lac, in both of which India has a world monopoly.

Instruments and Measurements Conference in Stockholm

Over 400 delegates from almost every country in the world, including the United States, attended the Conference on Instruments and Measurements and the concurrent International Exhibition of Measuring Instruments and Laboratory Equipment, held recently in Stockholm. During the conference 50 papers were read in five symposia:

1. Industrial Spectroscopy—17 papers.
2. Testing of Materials and Mechanical Measurements—8 papers.
3. Industrial Control—9 papers.
5. General and Miscellaneous Subjects—9 papers.

Following are the titles of the seven papers presented in the Metrology Symposium: "Mikrokator Magnifier and its application to Measurement of Length and Force", by H. Abramson (Swedish); "Measuring Methods in Machinability Research", by Prof. O. Svahn (Swedish); "Efficient Inspection of Parts Produced in Large Quantities", by J. Loxham (English); "Standard of Length and Angle for Precision Engineering", by H. Barrell, Metrology Division, National Physical Laboratory of Great Britain; "The Art of Measurement in Industry", by W. Ruggaber (German); "Glass Gauges", by V. Hruba (German); "A Comparator for High Precision Measurements of Anglesby the Interferometric Method", by G. Cassinis.

The full text of all papers presented at the conference are to be published early next year by the National Physical Laboratory of Great Britain.

A new method for the production of heavy duty refractory materials, claimed to eliminate the use of furnaces and based on a rapid process, has been developed by Professor R. L. Pevzner. The new refractory thus produced is called "thermitomullite," and its quality is said to be about equal to the best-grade electrocast mullite.

The new method is based on the thermal process for the recovery of metal free of carbon, such as chrome, manganese, tungsten and titanium. The new method is said to produce a high thermal effect, up to 3000 det C, is said not to have been used anywhere for the production of refractory materials.

The raw material, secondary metallic aluminum, metallic oxide and other materials, is cleaned and dried, after which it is melted in ladles, crucibles or other similar devices. To ignite the mixture, magnesium shavings with the addition of saltpetre, may be used. The melting takes one or two minutes, at a temperature of more than 2000 C.

The examination of "thermomullite" at the Geological Institute of the Academy of Sciences of the USSR has shown it possesses high mechanical durability and "refractoriness". Large scale tests in industrial furnaces have been started.

High Temperature Alloys Tested at Super-High-Speed

IN A "BOMB-PROOF" DUGOUT at the Westinghouse Research Laboratories scientists are exploding whirling, red-hot disks of metal in an effort to determine the maximum strength of parts for aircraft jet engines. Disks of special alloys, one foot in diameter and one inch thick, will be heated to temperatures above 1,400 deg. F. and spun at the speed of 1,200 m.p.h. (35,000 rev. per min.) until they literally fly apart under the combined attack of centrifugal force and heat.

The disks will be placed in the center of a specially constructed dugout, ringed with heavy sandbags and attached to the shaft of an ultra-high speed motor which is located 10 feet below the "dugout" floor. Electric heating coils provide the high temperature required. During testing the 32-lb. disks are covered by thin steel hoods from which air has been evacuated to reduce friction. The hoods are constructed of ⅛ in. steel, so that flying fragments of the metal will easily penetrate them. Use of a heavier steel would cause serious damage to the fragments and prevent close scrutiny of the type of fracture or break involved.

As the heated disk spins, research engineers will make continuous measurement of its temperature. Methods for doing this posed a difficult problem. Since the disk is whirling at the rate of 35,000 rev. per min., any thermocouple attached to the outer rim would have a centrifugal pull of approximately 190,000 times its own weight and would have to be fastened strongly enough to resist a pull of many thousand pounds. The problem was solved by a special welding process.

Periodic measurements also will be made of the expanding diameter of the whirling metal disk. Under high stress and temperature, all metals tend to creep, and with the very narrow clearances in the gas turbine, a knowledge of this rate of creep is vital.

These destruction tests are aimed at revealing the ultimate strength of alloys now used in gas-turbine rotors for jet engine application. In actual service, these rotors are subjected to terrific stress and temperatures. It is planned to simulate and even exceed those conditions until the metal breaks up in the hope of deriving a set of principles from which behavior of alloys at any temperature and speed can be predicted. Such knowledge of the physical limitations of metals will be valuable both in designing present aviation gas turbines and in pointing the way to the development of new and stronger alloys.

The "lid" goes on as scientists at the Westinghouse Research Laboratories prepare to explode spinning disks of metal in experiments aimed at measuring the maximum strength of jet engine alloys. The shining disk in the center of the sandbag dugout is attached to a high-speed motor that whirls it at speeds up to 1,200 miles an hour, while heating coils raise its temperature to 1,400 degrees Fahrenheit. This pace is maintained until the disk literally flies apart.

Limits and Fits Standard Developed by ASA

A NEW AMERICAN STANDARD, to be used as a guide to the machine designer in keeping to a minimum the various tools and gages required to produce and inspect cylindrical holes and shafts or other component parts with cylindrical external surfaces, has been developed by a technical committee of the American Standards Association, according to P. G. Agnew, vice-president of that organization. The new standard, entitled Limits and Fits for Engineering and Manufacturing (B4.1-1947), is a partial revision of the Tentative American Standard on Tolerances, Allowances and Gages for Metal Fits approved in 192.5

Without such a guide, excessive variety in hole and shaft sizes may easily grow up. One large American concern carried on its drawings about eight hundred holes in sizes of one inch and below.

In the new American standard, a table of preferred basic sizes covers the range up to 4 in., inclusive, by as few as 46 diameters for holes and shafts. The inclusion of a table of this kind in a standard referring to fits between cylindrical parts is made for the first time.

Most industries use the "basic hole" system in which the minimum limit of all holes of a given nominal size is

kept constant and the maximum limit of the shaft is varied in accordance with the character of the required fit. The standard of 1925 was based exclusively on this system.

The new standard, however, also recognizes the "basic shaft" system which is used widely, for example, in the textile machinery industry. Here, the maximum limit of all shafts of a given nominal size is kept constant and the minimum limit of the hole is varied so as to get the required fit.

The new standard also recommends the use of a series of preferred tolerances and allowances, to keep down the variety of limiting dimensions of component parts and hence, the cost of manufacturing.

A series of definitions of terms applicable to a system of limits and fits are given in the new standard. These definitions have been agreed on by representatives of the American, British and Canadian national standards bodies.

The new standard is intended primarily for application to fits between cylindrical parts, but may be used also for fits between parts of a different kind, such as a shafting key and the keyway in which it is to be inserted.

Lightweight Gas Turbines Developed by Boeing

TWO NEW LIGHTWEIGHT GAS TURBINE ENGINES have been announced by the Boeing Aircraft Co., Seattle, as part of a long-range power plant research program. First gas turbine engines in their power class, the Boeing model 500 turbo-jet produces 150 lb. of thrust yet weighs only 85 lb. while the model 502 turbo-prop delivers 200 shaft hp. and weighs 140 lb.

The model 500 turbo-jet engine is 29 in. long by 22 in. in maximum diameter. High velocity exhaust gases, heated to 1,500 degrees F. in two burner chambers, drive a 7½-in. turbine wheel. The turbine and its compressor are attached to opposite ends of a common shaft. Constantly expanding gases rush through the turbine and exhaust through a tail pipe, creating thrust, or forward movement.

The Boeing Model 502 turbo-prop is basically the same as the Model 500 with an additional turbine wheel turning the propeller shaft through a gear box. In addition to developing 200 hp., the Boeing 502 also exerts 50 lb. of thrust. This engine is 42 in. long by 22 in. in maximum diameter. It is adaptable to aircraft or boat use, and has possibilities as a fixed power source.

Improved Ice Calorimeter In High-Temperature Research

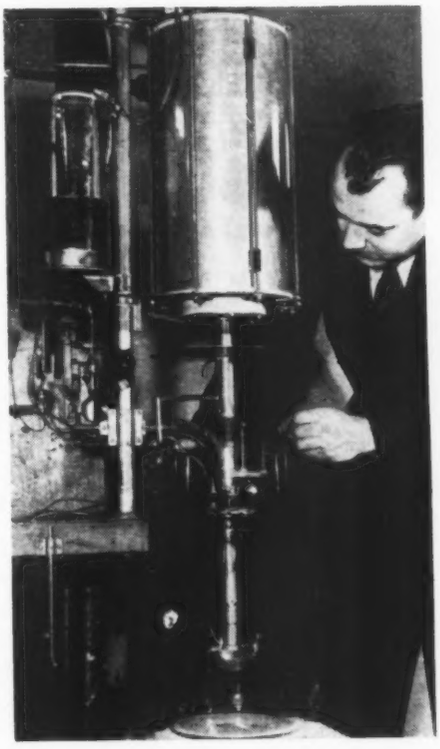
RESEARCH ON HIGH-TEMPERATURE SPECIFIC HEATS in the Heat Measurements Laboratory of the National Bureau of Standards has resulted in the development of a modified Bunsen ice calorimeter comparable in precision of results with the best of the present-day electric calorimeters, and at the same time offering certain advantages over such instruments. The instrument was constructed specifically for use in conjunction with a high temperature electric furnace to obtain specific heats and related thermo-dynamic data at elevated temperatures. In addition, this new ice calorimeter has provided the most accurate means for measuring the density of ice at its melting temperature, since it is free from many of the difficulties inherent in other methods.

In the application of the ice calorimeter to specific heat determinations, a sealed capsule containing the sample material is first heated to a known temperature in an electric furnace. The capsule is then dropped into the ice calorimeter, where the heat evolved in cooling to the temperature of melting ice is measured.

The ice calorimeter, by measuring volume changes taking place during the melting of ice, measures heat input by weighing mercury. In other words, the heat given off by the capsule and contents is allowed to melt ice that is in equilibrium with water in a closed system, and the resulting volume decrease is determined by means of mercury drawn into the system.

The furnace used with the ice calorimeter at the Bureau consists of a vertical alundum tube, one inch in diameter, having a chromel winding, and surrounded by insulation. Tests at temperatures up to 1000°C with thermocouple junctions located at various points within the furnace indicated that, under optimum conditions, gradients of only a few tenths of a degree per inch still existed in the central region in which the capsule was to be suspended.

The calorimeter is provided with a thin-walled central well of low thermal conductivity, into which the capsule containing the sample is dropped after heating to the desired temperature in the furnace above. The lower part of the well is surrounded by two coaxial glass vessels, which provide an insulating space between an inner ice-water system and a surrounding ice bath. The space between the central well and the inner glass is filled with air-free water, which is partially frozen at the beginning of an experiment. Any change in volume due to melting ice in the inner vessel is transmitted to a mercury reservoir, resulting in a change in the amount of mercury in a weighed beaker.



Operation of the specially designed radiation gate of the improved Bunsen ice calorimeter, developed at the National Bureau of Standards, is demonstrated by D. C. Ginnings, scientist in charge of high-temperature research. The sample material is first heated to a known temperature in the cylindrical resistance furnace (upper center) and is then dropped into the central well of the calorimeter where the heat evolved in cooling to 0 deg. C is measured.

The high-temperature specific heat apparatus was originally designed and constructed during the war for the atomic bomb project. After a series of calibration experiments, the specific heats of uranium metal and some of its salts were measured. The Bureau has also furnished high-temperature specific-heat data upon several substances requested by industry.

Information on the thermal properties at high temperatures of certain materials, particularly metals and ceramics, is needed in such fields as metallurgy and engineering-equipment design. In metallurgical processes it is often of importance to know the heat required to change the temperature of a metal or to melt it. In the design of chemical or other equipment to be used at high temperatures the engineer must consider such factors as the heat to be

supplied to raise the temperature of the starting materials, or the heat to be removed to lower the temperature of the products or the heat developed or absorbed that must be transferred through the walls of the apparatus.

SAE Developing New Data On Cold-Drawn Steels

PREPARATION OF STANDARD SPECIFICATIONS for cold-drawn steels has been undertaken by a new division, XVII, cold-drawn steels, of the SAE's Iron and Steel Technical Committee. The project is viewed as a step toward wider use of these basic materials in the automotive industries with consequent savings in time and production costs and betterment of such parts as studs, bolts, shafts, pinions, axle tubes, frame supports, and shackle pins.

Initial work of the division, comparative testing of automobile propeller shafts made from 125,000 psi cold-drawn, cold-drawn stress-relieved and heat-treated steels, is designed to establish physical properties and to suggest potential applications. The tests further are intended to substantiate present beliefs that a wide range of physical properties of steel can be developed by cold-working which, accelerating machining operations by two to six times those of heat-treated steel and drastically curbing losses in the process, afford substantial savings in production time and costs. Data will be sought on retention of impact strength, relieving trapped stresses, and relative shear, all in comparison with hot-rolled steel.

The project is an outgrowth of a wartime recommendation by Army Ordnance that the Society of Automotive Engineers sponsor these studies.

DISCUSSIONS AND COMMENTS FROM READERS

Standard Drafting Practice

To the Editor:

I have read the article "Basic Standard Drafting Practice" by G. E. Rowbotham, published in the July issue of PRODUCT ENGINEERING and agree wholeheartedly with Mr. Rowbotham's ideas regarding this subject.

We have been trying to compile such a drafting room manual for our own department which would necessarily be much smaller than the manual suggested in the article, but the basic ideas in compiling one would be the same. We would like to obtain a copy of some of these manuals from other companies but do not know how to go about it and are wondering if you could advise us. In other words, is it possible to purchase or otherwise obtain one of the drafting room manuals from one of the automotive companies, such as General Motors or Ford? Our idea is not to copy such a manual but to use one of them as a guide.

We would greatly appreciate any information you can give us on this subject.

—V. F. FRYE
Chief Engineer
U.S. Slicing Machine Co.

To the Editor:

I wish to thank Mr. Frye for his friendly interest in my artcile, and recommend that he purchase a copy of the "Chevrolet Draftsman's Handbook".

The handbook sells for forty cents and may be purchased from Chevrolet-Central Office, General Motors Corp., General Motors Building, Detroit 2, Michigan.

Other manuals worthwhile reviewing are: The SAE Aeronautical Drafting Manual which may be purchased from the Society of Automotive Engineers, Inc., 29 W. 39th St., New York 18, N. Y.; The ATSC Drafting Room Manual 57-0-2 released by Headquarters, Air Technical Service Command, Army Air Forces, Wright Field, Dayton, Ohio; The Ordnance Department Drafting Room Regulations released by the office, Chief of Ordnance, United States Army, Pentagon Building, Washington, D. C.; and individual company manuals compiled by various concerns throughout the country.

Any further help which we may be in a position to offer with regard to drafting practice will be forthcoming on request.

—G. E. ROWBOTHAM

Defends Industrial Research By Universities

To the Editor:

Mr. Toulmin's comments are, in part, well justified, and with these one can agree. There are others that seem to be based on misconception, or on a point of view that calls for clarification; on these I wish to comment.

His title, which is a positive assertion, is perhaps journalistic exaggeration. "Commercial" research by universities as distinguished from that done by research foundations can hardly be considered a threat to either science or education. Perhaps the implication is intended that universities which have organized research foundations as separate corporate entities have been neither sufficiently careful to assure separate management of the foundation, nor sufficiently meticulous in separating the physical facilities and personnel of the two institutions. Without such separation, confusion as to functions and operations is likely to result.

Similar confusion seems to beset Mr. Toulmin when he states that research foundations affiliated with universities have the primary function of developing new scientists and delve into the basic fundamentals of natural laws. This, from my observation, is not the case. Is it not fact rather than research, to apply rather than discover "the basic fundamentals of natural laws"? So long as the foundation does not pretend to be "purer"—in the sense of devotion to "pure" research—than it is, I can see no ground for criticizing it for not developing new scientists. But, as a matter of fact, isn't it doing so? If we need more workers in applied science, is not training in the laboratories of a research foundation as effective a factor in the training of "new scientists" as some other kinds of training might be?

On the other hand, if by "developing new scientists" Mr. Toulin means that young men should receive training in the fundamentals of physics, chemistry, and mathematics in such measure that they may become qualified to do independent research of whatever kind, I differ with him as to where the obligation rests to provide that training. To me it seems clear that this is solely the function of the university. And this function is unquestionably recognized by universities as their obligation. True, more scientists are needed. Their training through the master's or doctor's level is being done by universities. If it is this kind of education in science that Mr. Toulmin thinks is threatened. I doubt that he is right in his belief.

A research foundation affiliated with a university is likely to become a fair target for criticism unless it exercises extreme care to avoid unfair competition with commercial agencies which exist for the same purpose. By unfair competition I mean the thing Mr. Toulmin condemns, namely, the doing of "cheap" research for industry. They can do it "cheap" because the university's accounting system ignores overhead items which the commercial consultant cannot overlook. Moreover, if its charter calls the foundation "nonprofit," it may not have the tax burden to which the commercial consultant is

subject. It seems hardly cricket that a foundation, perhaps under control of a university administration, should engage in a demoralizing kind of competition with university alumni, perhaps from the same institution, which the university has trained for the careers they are following. Nonetheless—granted that some foundations are doing "cheap" research for industry—this still does not constitute a threat to science and education.

Too many foundations have, I surmise, been promoted under the illusion that they would inevitably produce a sizeable income for the university. Their promoters were probably spurred on by the example of the Wisconsin foundation. But the spectacular success of the Wisconsin Alumni Research Foundation (which, contrary to Mr. Toulmin's implication, was not organized by, and is not under the control of the University of Wisconsin) is not likely to be repeated in any other foundation. Expectation—or hope—of large income for the support of research from patents resulting from work of the foundation is almost certainly foredoomed to disappointment.

At Northwestern University there is no research foundation. The Technological Institute is its school of technology, which has as its primary function the training of students in engineering and applied science, including training at graduate levels to the doctorate. In the thinking of those responsible for its development, research is unquestionably an essential function of such an institution. The research function makes for more competent, better known teachers, and for better training of its students particularly at the upper levels. It must not be forgotten that engineering is, in essence, applied science, and that therefore engineering research is bound to have a developmental flavor. However, there are problems of applied research as basic to engineering as are the problems in "pure" research to physics, chemistry, and the other fundamental sciences.

So long as the engineers and scientists on a university staff confine their researches to the things that are fundamental in their respective fields, there is small likelihood that bedevilment by "commercial" or patent perplexities will arise. Should there be patentable invention in a research project done under university auspices, the university, as a public institution, has an obligation to see that administration of the patent is in the public interest. At the same time, the university must erect safeguards against its becoming involved in litigation, or against having to become actively engaged in the commercialization of patents. Any financial benefits accruing to the university or its staff by the route of research must be regarded as incidental, and financial returns must not be a motive in the research. The university should confine its research to an unrestricted and uninhibited search for basic knowledge. In so doing, it will be contributing in full measure to the social and economic welfare of the public, for basic knowledge is the grist for the mill of industrial research; or, to change the metaphor, it is the solid foundation on which the structure of our material civilization is built.

Mr. Toulmin's comment that it is "fatal for commercial laboratories to go too far into fundamental research" makes one wish that he had given examples. Examples to the contrary can be cited. Two large commercial laboratories of this country have Nobel prize winners in pure science, for work done in those laboratories. Although it is true that an industrial laboratory can offer salaries so much in excess of salaries in universities that "they tend to entice the ablest scientists away from the universities where they belong," there has been no overwhelming evidence even in these times of almost frenzied competition that the "ablest" scientists are drifting into industry. As a matter of fact, some very able scientists have within the past few years made a change in the opposite direction. There is no doubt about the shortage of scientists; but when in the next five or six years we have again approached equilibrium between supply and demand, the universities will not have to worry at all about migration of their ablest men into industry. Those who feel drawn to the kind of research that requires opportunity for undisturbed contemplation and for uninterrupted experimentation are quite likely to act on the conviction that the university atmosphere is more conducive than is that of the commercial laboratory to this method of doing creative work.

Finally, it seems to me that if universities with associated research foundations take great care first to formulate explicitly the purposes and functions of the foundation, and second, to provide safeguards against confusing those functions with the normal functions of the university, the threat implied in the title of Mr. Toulmin's article will completely vanish.

—Paul E. Klopsteg
Director of Research
Northwestern Technological Institute

MEETINGS

October 9-10
Porcelain Enamel Institute—Annual Meeting, Cleveland, Ohio.

October 16-17
National Conference on Industrial Hydraulics—Third annual meeting, Sheraton Hotel, Chicago, Ill.

October 18-25
American Society for Metals—National Metal Congress, International Amphitheatre, Chicago.

October 20-21
Society of Automotive Engineers—Production Meeting, Carter Hotel, Cleveland, Ohio.

October 20-22
American Society of Mechanical Engineers—Fuels Div., Joint Meeting with the Coal Division of the American Institute of Mining and Metallurgical Engineers, Cincinnati, Ohio.

October 20-23
American Institute of Mining and Metallurgical Engineers—Iron and Steel Div. and Institute of Metals Div., Annual Meeting, Stevens Hotel, Chicago, Ill.

October 20-24
American Society for Metals—Annual Meeting, Palmer House, Chicago.

October 20-24
American Welding Society—Annual Meeting, Sherman Hotel Chicago, Ill.

October 21-25
Pacific Industrial Conferences—Concurrent with Pacific Chemical Exposition, San Francisco Civic Auditorium, San Francisco, Cal.

October 23-25
Optical Society of America—Thirty-Second Annual Meeting, Netherland Plaza, Cincinnati, Ohio.

November 3-5
National Electronics Conference—Sponsored by the **American Institute of Electrical Engineers**, and the **Institute of Radio Engineers**; Edgewater Beach Hotel, Chicago.

November 5-7
American Society of Body Engineers—Annual convention, Rackham Memorial Bldg., Detroit, Mich.

November 6-7
Society of Automotive Engineers—Fuels and Lubricants meeting, Mayo Hotel, Tulsa, Okla.

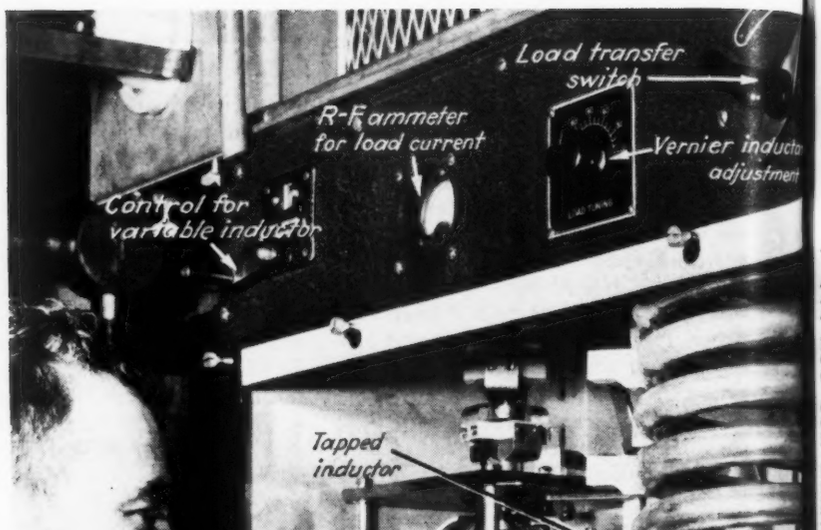
December 1-3
Society of Automotive Engineers—Air Transport Meeting, Hotel Continental, Kansas City, Mo.

December 1-6
Twenty-First Chemical Industries Exposition—Grand Central Palace, New York, N. Y.

DIELECTRIC HEATING

How to determine when dielectric heating is desirable and can be applied with profit in industry.

B. E. RECTOR
Electronic Engineer,
Westinghouse Electric Corporation



Adjusting the inductance of the load network to tune it to the load

MOST of the possible uses for dielectric heating must be analyzed carefully to determine whether or not this electronic method of generating heat is desirable and profitable. For example, in addition to basic considerations such as the characteristics of the material to be heated, a convenient steam line, available wood scrap, or similar local conditions may be the deciding factor. Each application should be judged on its own merit.

In dielectric heating, the material to be heated is generally a non-conductor of electricity such as wood. plastics, rubber, or textiles. In the heating operation the material is placed between two metallic surfaces or metal sheets that are energized by high frequency power generators supplying 2 to 200 million cycles per sec. at voltage up to 15,000 or more. A typical circuit is shown in Fig. 1 for high frequency heating.

Dielectric heating imparts heat instantaneously to the core and external surfaces of the material with approximately equal intensity. Thus, getting heat inside the material does not depend upon the heat conductivity of the material.

Six Application Factors

When considering the use of dielectric heating, factors that should be analyzed include:

1. Properties of the material to be heated; size, shape, and electrical characteristics.
2. Increased functional and sales values by using dielectric heating.
3. Effect on cost of manufacturing the product.
4. Changes in machine operating costs or cost of process performed by the machine or product when used by the customer.
5. Differences in maintenance costs, including replacement of parts.
6. Relative technological considerations of electronic operation.

In general for uniformity of heating the dielectric material to be heated should be uniform in thickness and reasonably homogeneous. But there are ways of heating certain types of non-uniform shaped sections uniformly. Sometimes two pieces, such as wedge shaped parts, can be placed in complementary positions to give uniform thickness. Also sometimes the electrodes can be spaced so they are away from the thinnest section of the material to be heated and near at the thickest section, or even in contact with the material. This method is relatively critical for production processes and usually should be avoided.

Compared with other heating methods, advantages of dielectric heating include: Faster and more efficient production, less labor, reduced space, increased cleanliness of operation, higher quality of the product, and combinations of these factors.

Dielectric materials are usually poor conductors of heat as well as of electricity. In conventional heating processes the importance of heat conduction increases with the thickness

Table I—Characteristics of Dielectric Materials

General Note: Correct all power factors for distributed capacity of electrodes and shielding

NAME	Density gm/cc	Density lb/in.³	Sp. ht.	e = power factor, e′ = dielectric constant, e″ = loss factor — 1 mc e	1 mc e′	1 mc e″	5 mc e	5 mc e′	5 mc e″	10 mc e	10 mc e′	10 mc e″	15 mc e	15 mc e′	15 mc e″	30 mc e	30 mc e′	30 mc e″
Amber (Softens, 250 deg. C)	1.1	0.04		0.002	2.9	0.0058												
Asbestos sheet	0.5	0.0181	0.195	0.32	4.6	1.46	0.21	4.1	0.85	0.15	3.9	0.585	0.12	3.8	0.456	0.08	3.3	0.264
Asbestos sheet impregnated with thermosetting plastic													0.0015	1.022	0.00153			
Beeswax, yellow (Softens, 60 deg. C)	0.96	0.0348		0.016	3.2	0.0511												
Cellulose acetate			0.45	0.099	4.6	0.455												
Cellulose nitrate (Softens, 60–90 deg. C)	1.42	0.053	0.36	0.085	6.18	0.525												
Chocolate — cake form																0.0241	3.26	0.0786
Cottonseed																		0.04
Fibre-bone — vulcanized	1.3	0.047		0.05	5.75	0.25–0.27												
Fibreboard — grey																0.085	5.1	0.434
Fibre sheet — C-598																0.066	4.1	0.27
Fibre sheet — Spauldite GB-1																0.034	4.43	0.15
Insanol or Mycalex (insulator)				0.001	7.5	0.0075	0.001	7.5	0.0075	0.001	7.5	0.0075	0.001	7.5	0.0075	0.0012	7.5	0.0093
Nylon (small samples)			0.55	0.028	3.3	0.0925	0.024	3.3	0.079	0.024	3.3	0.079	0.024	3.25	0.078	0.022	3.2	0.075
Paper — corrugated asphalt impregnated							0.022	1.42	0.0315	0.022	1.42	0.0315	0.020	1.42	0.024	0.020	1.4	0.028
Plexiglas							0.022	2.78	0.061							0.017	2.78	0.047
Rubber — Pure Gum										0.007	2.15	0.015				0.01	2.15	0.0215
95% uncured	2.4	0.0866								0.012	3.25	0.039				0.012	3.2	0.0384
95% cured	3.6	0.13								0.037	4.0	0.148				0.03	4.0	0.12
Medium grade uncured	4.5	0.162								0.018	5.0	0.090				0.015	5.0	0.075
Medium grade cured	4.3	0.155								0.10	6.0	0.60				0.082	5.8	0.475
Low grade uncured	4.6	0.166								0.02	6.0	0.12				0.018	5.9	0.106
Low grade cured	4.2	0.152								0.103	7.4	0.764				0.068	6.9	0.47
Reclaimed	5.6	0.202								0.03	4.6	0.138				0.025	4.5	0.113
Pure pale crepe										0.004	2.1	0.0084	0.004	2.1	0.0034	0.005	2.2	0.0105
Buna S — pure										0.006	2.20	0.0132	0.006	2.2	0.0132	0.007	2.2	0.0154
With carbon black																0.028	10.7	0.29
Synthetic — crumb																0.00281	1.67	0.00467
Shellac	1.01	0.0364		0.009	3.1	0.028												
Soya bean oil (Softens, − 10 deg. C)	0.925	0.0334	0.5							0.098	1.9	0.175	0.088	2.3	0.21	0.07	2.5	0.175
Tobacco — green uncured										0.168	2.57	0.432						
Twine, paper, spools 20% moisture										0.07	2.4	0.16						
Wheel — grinding 85% alundum										0.031	6.9	0.214				0.038	6.5	0.247
Wheel — grinding 80% alundum										0.067	11.4	0.765						
Wood — Birch	0.63	0.0238		0.0648	5.2	0.337												
Maple	0.62	0.0224		0.033	4.4	0.145												
Oak	0.69	0.025		0.0385	3.3	0.127												
Plywood (Fir)	0.41	0.0148								0.035	3.1	0.1085						

Note: Sp. heat of wood = 0.226 + 0.000644 (T − 32), where T is deg. F.

of the material. To get sufficient heat inside the material for a desired result, such as drying at satisfactory speed, the temperatures required are often high enough to damage the surface of the material. Plastics up to ½ in. thick or paper up to about ¼ in. thick, for example, can be heated with hot platens as well as dielectrically. But thicker sections of plastics or paper can be heated much more effectively by dielectric heating than by hot rolls or platens, which overheat the surfaces and in drying processes may seal moisture inside.

Dielectric heat can be applied to cut sheet material by squeezing it between metal electrodes, or to continuous strip by passing it between the electrodes. The latter technique reduces the required size of electrodes, simplifies keeping a uniform electric field between the electrodes, and often offers advantages in the batch production of single sheets.

Besides avoiding the difficulties resulting from low rate of heat conduc-

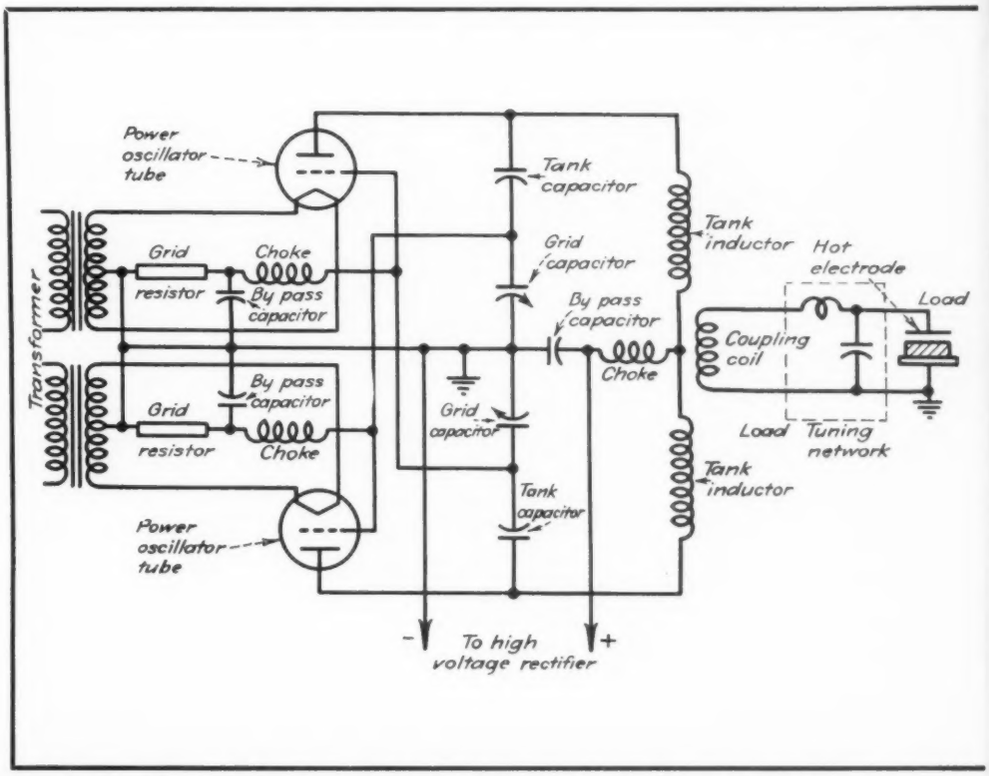


Fig. 1—Circuit schematic for typical dielectric heating unit used in industry.

tion, control of dielectric heating is simple and the rate of heat input to the material can be held more accurately than with hot platens or rolls. In dielectric heating the heat produced simultaneously in every particle of the material can be timed precisely. When heat originates from hot platens or rolls, it takes time to change their temperature, and time for the heat to penetrate into the material.

Machines for dielectric heating are simpler to design and build than are machines that apply heat by means of steam, hot water, or gas with their cumbersome piping and flexible connections. The electric power generator is usually a separate unit and is connected to electrodes on, or adjacent to, the machine. Generally, a machine using dielectric heating occupies less space than one using hot water or steam. The dollar savings in piping, valves, and platens or rolls is usually more than offset by the cost of the high frequency generator.

The cost of operating a dielectrically heated machine is always much higher than one heated by steam or hot water. This is especially so if steam is generated by burning scrap wood, sawdust, or other by-products of a manufacturing operation.

The basic operating cost of radio frequency generators is shown in Fig. 2. The three main costs are: Tube replacement, power, and amortization of original investment.

Maintenace is more costly with hot water or steam heating; hot rolls or platens must be kept in good condition, pipes and fittings sometimes have to be replaced, and joints and valves must be repacked periodically. Such maintenance stops the machine for varying lengths of time, but replacement of tubes from stock is done in a few minutes.

Rate of Heating

Physical and electrical characteristics of the material affect the rate of heat generation and hence the approximate rate of increase in temperature rise. Where:

W = rate of heating, watts
A = area of electrode, sq. in.
d = thickness of material, in.
f = frequency, cycles per sec.
E = voltage, r.m.s.
e'' = loss factor of material (dielectric constant × power factor)

The rate of heating dielectric materials can be calculated by,

$$W = \frac{1.41\ AfE^2e''}{10^{12}\ d}$$

For successful dielectric heating, the electrical resistivity of the material, (not in formula) usually should be greater than 1,000 ohm-centimeters. This limit varies depending on the thermal conductivity and other characteristics.

The rate of heat generation in a material at a given voltage is proportional to the square of the voltage applied across the material. Thus, if it is desired to double the rate of temperature rise, W will double and E will be increased by $\sqrt{2}$. Since for most applications all factors in the equation excepting E and f are known, often an application is a compromise of these two factors. By doubling the frequency, the voltage across the material is reduced by $\sqrt{2}$. To keep the voltage within reasonable limits, the frequency should be as high as practicable. The two factors that limit the increase in frequency are voltage distribution and oscillator design.

The maximum permissable voltage is limited by arc-overs and corona. Frequency is limited by the increasing nonuniformity of voltage distribution, particularly when the electrode areas are large. The capacitive reactance of a large area may be so low that "tuning the load" is extremely difficult, or impossible. The large currents produced may be difficult to control. Long loads may produce standing waves that cause uneven heating.

For a given maximum operating voltage, the rate of heating cannot be indefinitely increased by increasing the area of electrodes because the frequency must be decreased. Using the smallest effective area that gives a favorable voltage distribution across the face of the electrodes, sometimes permits use of a higher frequency.

The equation shows that power input is directly proportional to the loss factor of the material being heated. The loss factor is a measure of the energy absorbing ability of the material when in a varying electrical field. The specific inductive capacity and power factor determine the loss factor. The practical lower limit appears to be between 0.005 and 0.01. Polystyrene and quartz, for examples, have lower values and are difficult to heat dielectrically. The upper limit is determined by electrical conductivity of the material, a point being reached where the material responds to inductive fields. Usually the loss factor of a material has to be determined by tests. Since it usually varies with frequency, temperature, and moisture content, measurements are made for the expected variations of the material before and during heating.

Standards established by NEMA are based on the power output of the unit rather than power input. Ratings are 2, 5, 10, 20, 50, 100, and 200 kw. Up to 20 kw., frequencies up to 27.3 megacycles are used. Above 20 kw. frequencies as high as 13.6 megacycles are available. For frequencies up to 200 megacycles present generators are limited to a few hundred watts. Most production applications use frequencies between 2 and 30 megacycles. Practically, above 20 kw. frequencies of less than 20 megacycles appear desirable. Increasing the frequency to increase output of generators is limited because this intensifies unequal voltage distribution between electrodes.

Potentials of less than 20,000 volts between electrodes minimize corona and arc-overs. Since the dielectric material may be punctured, the prob-

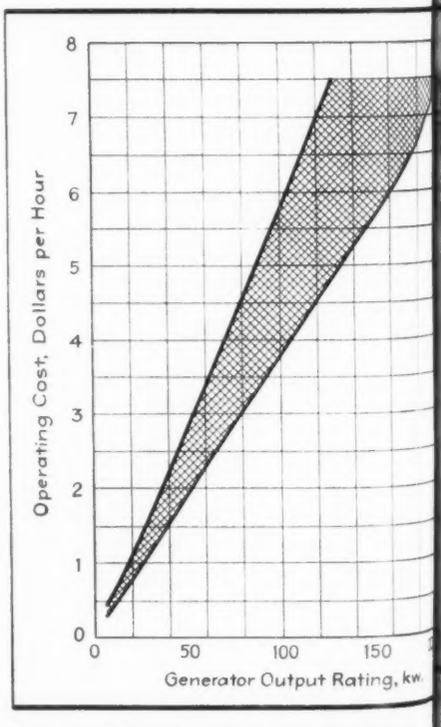


Fig. 2—Approximate basic operating cost in dollars per hour for dielectric heating units ranging from 3 to 200 kw.

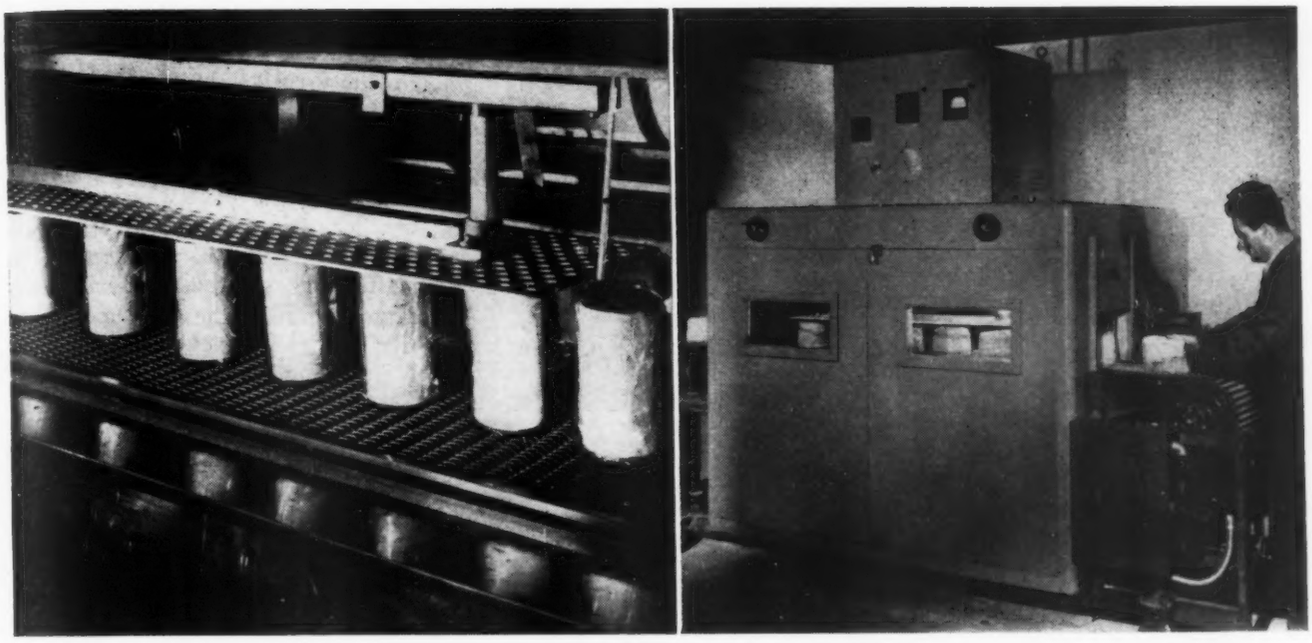


Fig. 3—Spools of rayon and nylon are quickly twist set by high frequency heating in this textile application. (Right) Loading material on conveyor; (left) Spools passing between electrodes inside oven.

able voltage gradient usually is less than 2,000 volts per in. in porous materials and less than 5,000 volts per in. in dense materials. When the material must not touch the electrodes, such as Fig. 3, the voltage gradient in the air or other surrounding medium may cause breakdown at lower voltages.

Because of these electrical limitations, when heating large areas the frequency and rate of introducing energy into a material must be reduced. Scanning or moving the material across smaller electrodes sometimes increases speed and minimizes the nonuniform voltage distribution between electrodes.

In dielectric heating little heat is lost by conduction from the material to the electrodes. Generally, relatively thin sheets of low thermal capacity are used for the electrodes and a small amount of heat brings them to the temperature of the material being heated. If the electrodes are massive, sometimes steam or hot water can heat them to a temperature approaching that of the heated material. Sometimes it is practical to insulate the electrode thermally from the material.

The approximate operating cost for dielectric heating, in terms of B. t. u. input to the material being heated, ranges between 1 and 2 cents per 1,000 B. t. u. On the basis of cost per 1,000 B. t. u., heat produced by radiant lamps costs 0.25 to 1 cent and steam supplied to the press or other heat transfer medium costs approximately 0.01 to 0.7 cents exclusive of transmission and radiation losses.

Because such costs vary widely for different plants, dielectric heating may be economical for a process in one plant but uneconomical for a similar process in another plant.

Specific applications of dielectric heating to different materials show the influence of some of these factors. In drying paper the efficiency of dielectric heating depends to a large extent upon dielectric properties of the paper and its thickness. Generally ¼ in. air spaces separate electrode surfaces from the paper passing between them so the paper will not be marred by physical contact.

Satisfactory heating rates could be obtained with 500 volts across the paper. To develop 500 volts between the faces of the paper would require 150,000 volts across the electrodes. This is because of the difference in dielectric properties of air and wet paper. See Fig. 4. Heating a thin layer of paper at high rates is at best extremely difficult by conventional dielectric heating technique. If the paper thickness were ½ in. or more, dielectric heat might be superior to steam, particularly if electrodes can touch the material.

The possible advantage of using dielectric heating instead of heat drums for drying paper is because of paper's low thermal conductivity and the advantage increases with the thickness of the paper. Heated drums dry the outer surface first and seal moisture in the center. Dielectric heat dries the center first and supplies more energy to wet spots than to adjacent dry areas. This tends to dry the mass uniformly. In both

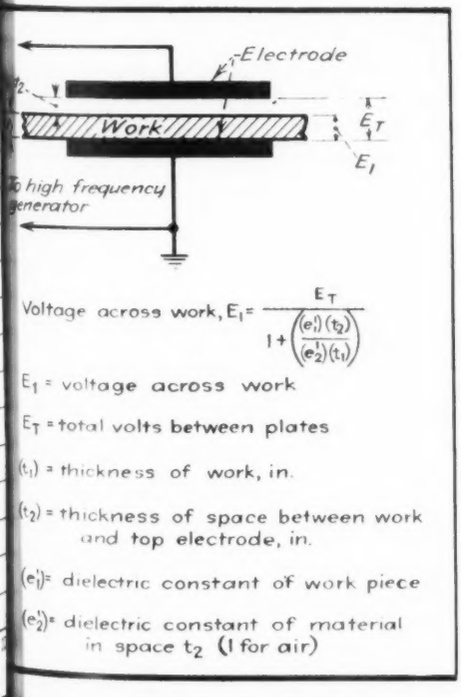

Electrode
Work
E_T
E_1
To high frequency generator
Voltage across work, $E_1 = \frac{E_T}{1+\left(\frac{(e_1')(t_2)}{(e_2')(t_1)}\right)}$
E_1 = voltage across work
E_T = total volts between plates
(t_1) = thickness of work, in.
(t_2) = thickness of space between work and top electrode, in.
(e_1') = dielectric constant of work piece
(e_2') = dielectric constant of material in space t_2 (1 for air)

Fig. 4—Voltage conditions across work when two materials of different dielectric constants are between electrodes.

Fig. 5—Heating plastic preforms with a 30 megacycle radio frequency generator.

methods a current of hot air removes the water vapor.

Experiments have been made to combine the efficacy of dielectric heating and the economy of steam heated drums. The core of the paper is heated first dielectrically to the desired temperature and then the less expensive steam-heated drums complete the drying.

Dielectric heating is efficient for some thin material, such as certain plastic impregnated paper and cloth that have favorable dielectric properties. In one application, substantial savings were made by changing from batch production of single sheets in presses to a continuous and more efficient roll process.

The controlling factors in the choice of heating method do not always have a direct relation to relative efficiencies of dielectric and other heating methods. Space requirements of equipment, reduction of time, and cleanliness of dielectric heating are sometimes important. Often such factors are favorable to dielectric heating.

In a typical application, a 25 lb. box of frozen apples is thawed in approximately 2 minutes by using a 20 kw., 13.6 megacycle R-F generator. Such quick thawing improves quality, requires less storage space, and provides more flexible use factor in different variety of types of frozen foods.

Dielectric heating is used for many processing operations including gluing and drying thick laminated wood members, scarf splices, wood and plastic propellers, and miscellaneous wood gluing operations for aircraft; preheating plastic material to the molding temperature; sealing bags of plastic material, or paraffin coated paper; edge joining sheet plastic; making thermoplastic seals in ceramic parts such as spark plugs; and drying and twist setting textiles.

A general use today is heating plastic preforms before molding, as shown in Fig. 5. Heat softens the material so time for closing the mold is reduced. On one large plastic part, for example, the time was reduced from several minutes to a few seconds. The time for curing was reduced from half to a fifth the normal time because the plastic and semifluid material conducts heat from the mold more rapidly.

Since mold pressures are also less, molds last longer or can be made of less expensive material. Because the lower pressure exerts much less force on the positioning pins, it is easier to use small, delicate inserts.

Future Uses

Proposed future uses of dielectric heating include many applications for sterilization, pasteurization, and dehydration of food. Breakfast foods may be sterilized in the package. Electronic heating may do a better job of defrosting bulky packages of frozen foods and fruits.

Dielectric heating is being tried for gluing optical lenses, furniture, slide rule blanks, paper, woodenware, door and door frames. The curing and drying of sponge rubber and sponge rubber products offers exceptional possibilities. Edge gluing and spot gluing by dielectric heating has attractive features for the wood working industries. In certain types of chemical reactions dielectric heating may become practical, for example, heat created by selective frequency may have a desired catalytic effect.

Dielectric heating has a promising future. Since it often can produce results not readily obtained by other methods, dielectric heating provides industry with an increasingly valuable tool. But it is not a cure all, since careful analysis and sound engineering judgment are necessary for the economical use of dielectric heating.

* * * *

IT HAS BEEN SAID that Dr. Rudolph Diesel attributed the discovery of the "diesel principle" to his visit with an old Samoan "firemaker". The Samoan used a section of bamboo, closed at the bottom, in which a plunger stick could travel. The plunger was depressed rapidly with a piece of dried moss attached to it. The moss ignited and an idea was formed. Dr. Diesel reasoned that if the temperature of the air could be raised to ignite moss it could also be used to ignite a low-cost fuel. He contemplated introducing coal dust into an internal combustion engine cylinder and igniting it with the hot air formed by a compression stroke. After meeting great difficulty with this fuel, he tried oil . . . . and the diesel engine was established.

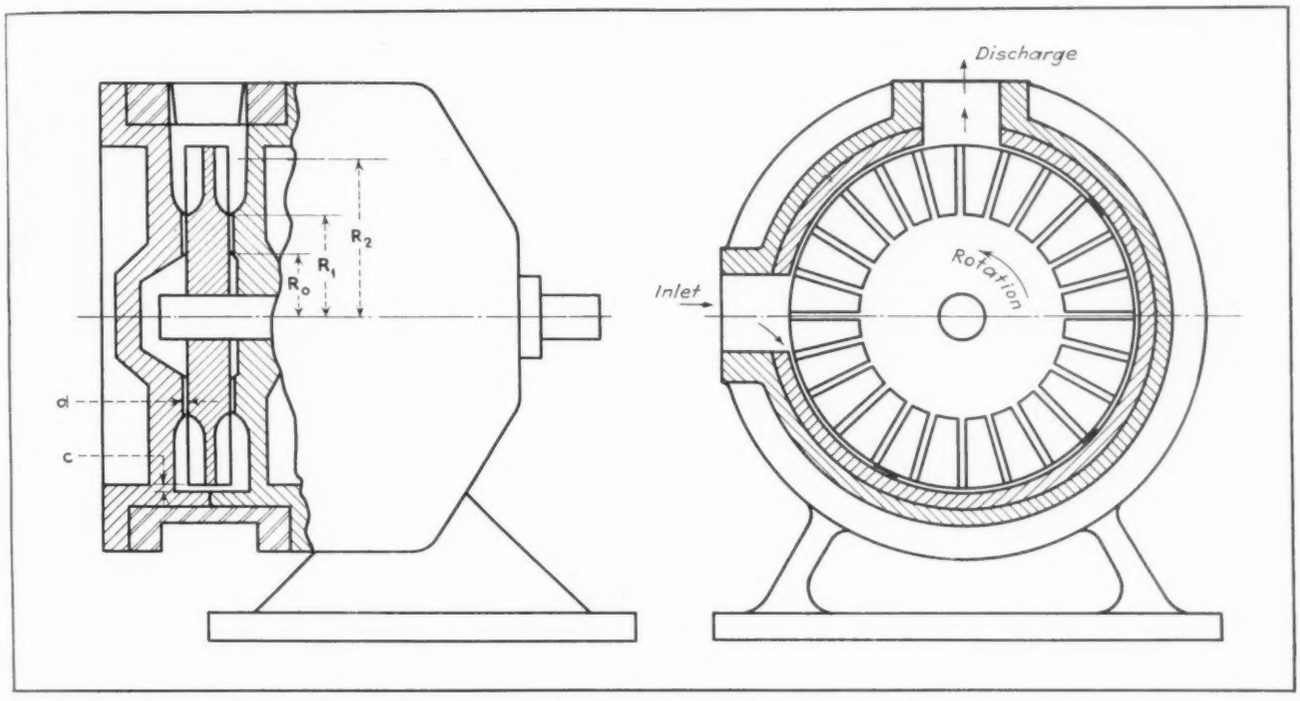


Fig. 1—Typical cross-sections through impeller and housing of a turbine pump used for pumping liquids of low viscosity.

Analysis of Turbine Pumps

WARREN E. WILSON
Director of Research, Sundstrand Machine Tool Company

Components of fluid flow and distribution of velocity of flow through turbine pumps and an analysis of their principles of operation. Laminar and turbulent flow patterns are discussed, and simplified characteristic equations are derived on the basis of certain ideal assumptions of pump geometry.

FOR pumping water and other liquids of low viscosity the turbine pump, which is sometimes known as the peripheral pump, has long been used. But there appears to be some possibility that this type of pump may have uses hitherto unsuspected because of the lack of a thorough understanding of its operating principles.

A theoretical analysis of turbine pump performance supported by some experimental evidence, was presented by Myagi and Miyadzu, (Tohoku Imperial University Reports Vol. 13, 1939.) These authors classify the turbine pump as a rotary pump. This classification is sound since the theory of operation of the rotary pump is adequate to account for the performance characteristics.

In Fig. 1 are shown typical cross-sections of a turbine pump. The distance c is the clearance between the impeller and the housing that provides the passage through which the liquid is transported. The distance R_2 is the distance from the axis of rotation to the centroid of the flow passage area. R_1 and R_o are the radial distances from the axis of rotation to the outer and inner boundaries of the sealing surfaces.

In operation, the liquid adheres

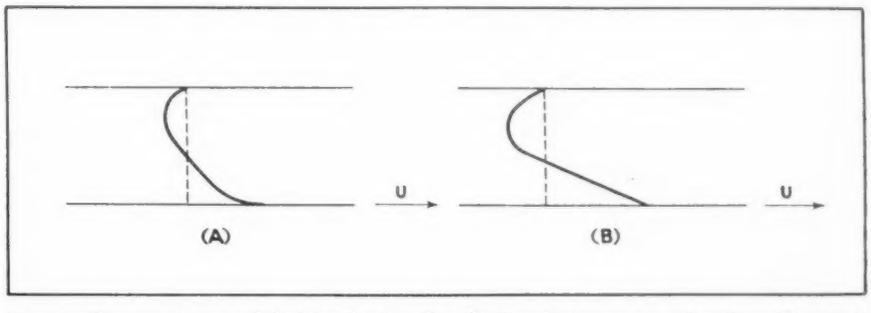


Fig. 2—Flow patterns of fluid velocity distribution between moving impeller and stationary housing when there is no pressure differential between the inlet and outlet. (A) gradient for tubulent flow. (B) Gradient for laminar flow.

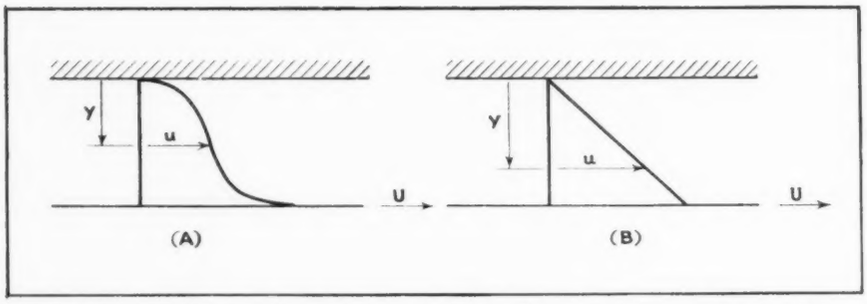


Fig. 3—Resultant flow patterns between the moving impeller and the stationary housing when pump builds up pressure. (A) Turbulent flow. (B) Laminar flow.

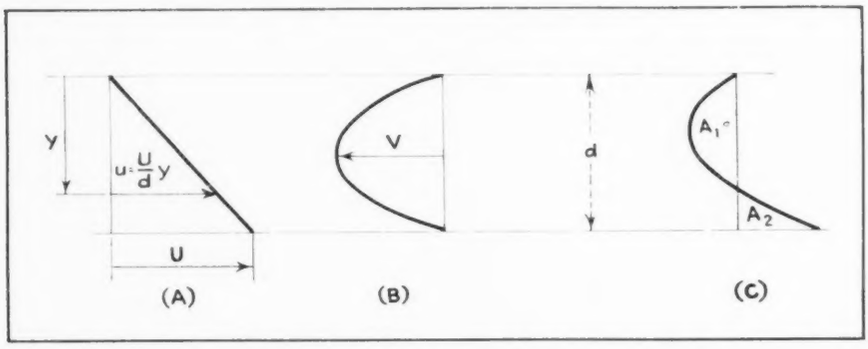


Fig. 4—Components and resultant flow in a turbine pump. (A) Flow caused by impeller. (B) Flow caused by pressure differential. (C) Combined flow.

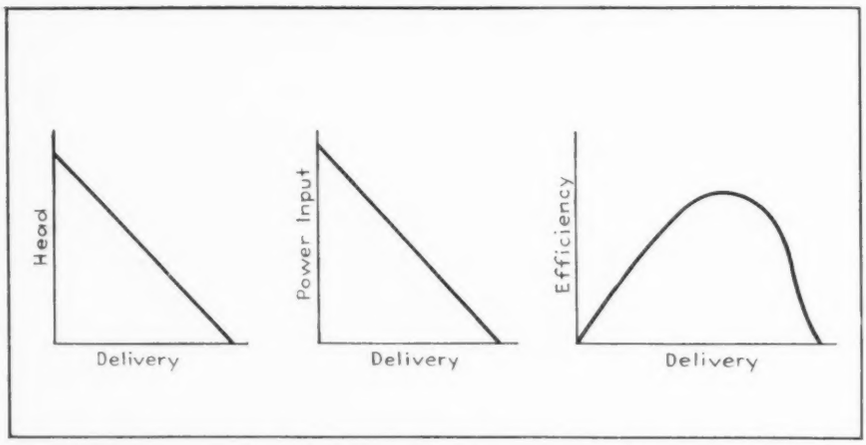


Fig. 5—Performance characteristics of turbine pump turning at constant speed.

to the rotating surface of the impeller and moves with it, but at the same time that liquid which is in contact with the stationary housing adheres to that surface. In consequence, when there is no pressure difference between inlet and outlet, the velocity distribution between moving impeller and stationary housing is of one or the other of the two general forms indicated in Fig. 2. In Fig. 2(*A*) the flow pattern, showing the velocity u at any point as a function of the distance y from the stationary wall, corresponds to the general form of the velocity gradient to be expected when the flow in the passage is turbulent. When the flow is laminar the pattern of Fig. 2(*B*) may be expected.

When a pressure is built up by the pump there is superimposed on the flow patterns of Fig. 2 a pattern corresponding to that caused by the pressure differential. Fig. 3 indicates the resulting flow patterns for the turbulent and laminar conditions.

The pump will continue to yield a net discharge against a pressure as long as the physical transport of fluid caused by the motion of the impeller exceeds the flow resulting from pressure differential. When the two are equal the maximum pressure differential, against which the pump will deliver fluid at a given speed of rotation, is attained.

This balancing of the transport of liquid by the impeller and the flow resulting from pressure is shown in Fig. 4 for laminar flow. The flow caused by the motion of the impeller is shown by the velocity diagram Fig. 4(*A*); here the variation of velocity with distance from the fixed surface is linear. The velocity distribution resulting from pressure difference alone is parabolic in form, Fig. 4 (*B*). The combined pattern is shown in Fig. 4 (*C*), where if the areas A_1 and A_2 under the curve are equal the net flow will be zero.

Simplified equations for the flow in the pump can be developed on the basis of certain assumptions. If the cross-section of the flow passage is considered to be a rectangle of width b and height c, and b is large compared to c, the equations for the quantity of flow through the passage can be developed readily.

Where:

Q = rate of flow, cubic units per time unit
c = depth of the passage, length units
b = width of the passage, length units
U = velocity of the moving plate, length units per time unit
P_1 = discharge pressure, force units per area unit
P_2 = intake pressure, force units per area unit
μ = coefficient of viscosity of the liquid, mass units divided by length and time units
l = length of the passage from inlet to discharge, length units

This flow condition can be approximated by the laminar flow between infinite parallel flat plates, which is described by the equation:

$$Q = \frac{Ucb}{2} - \frac{(P_1 - P_2)c^3b}{12\,\mu\,l} \qquad (1)$$

It is immediately apparent that this type of pump can never deliver more than one half the quantity per unit time represented by the product of the velocity of the impeller and the cross-sectional area of the flow passage.

The power required to drive the impeller is dependent upon the torque required to maintain the rotation against the resisting torques resulting from pressure differential, viscous shear and bearing friction. The shear S_1 at the surface of the impeller bordering the flow passage is caused principally by pressure differential. The shear S_2 at the sealing surface results principally from viscous

shearing of the liquid in the narrow passage of radius R_0, outer radius R_1 and clearance d. The shear stress S_1 on the passageway surface of area bl is

$$S_1 = \frac{\mu U}{c} + \left(\frac{P_1 - P_2}{l}\right)\frac{c}{2} \qquad (2)$$

Where u is the velocity of the moving impeller relative to the stationary housing at any distance R from the axis of rotation, the shear stress S_2 on the surface in the sealing area is

$$S_2 = \frac{\mu u}{d} + \left(\frac{P_1 - P_2}{l}\right)\frac{d}{2} \qquad (3)$$

It is apparent from a consideration of the magnitude of the terms in Equation (2) that the first term will in general be negligible compared to the second for any considerable pressure difference. Similarly in Equation (3), the second term will generally be negligible compared to the first. Consequently expressions for the torques T_1 and T_2 that result from shear are

$$T_1 = S_1\, blR_2 \qquad (4)$$

$$T_2 = \int_{R_0}^{R_1} 2\pi R^2 S_2 dR \qquad (5)$$

Therefore, neglecting bearing friction, the first term in Equation (2) and the second term in Equation (3), and substituting the angular velocity ω of the impeller times R for u, and integrating, the total resisting torque T_R is

$$T_R = T_1 + T_2 = (P_1 - P_2)\frac{cbR_2}{2} + \frac{\pi\mu\omega}{2d}(R_1^4 - R_0^4) \qquad (6)$$

The power input P_i required to drive the impeller is given by the general expression:

$$P_i = T_R\omega \qquad (7)$$

The power output P_0 of the pump is given by the general expression:

$$P_0 = Q(P_1 - P_2) \qquad (8)$$

Upon substituting for U in Equation (1) the quantity $R_2\ \omega$, Equation (8) becomes

$$P_0 = \left[R_2\frac{\omega cb}{2} - \frac{(P_1 - P_2)\,c^3 b}{12\mu l}\right]\times (P_1 - P_2) \qquad (9)$$

The efficiency E of the pump is

$$E = P_0/P_i \qquad (10)$$

Using the parameter

$$F = (P_1 - P_2)/\mu\omega$$

the Equation (10) for efficiency E can be rewritten in the form

$$E = \frac{1 - (Fc^2/6lR_2)}{1 + [\pi(R_1^4 - R_0^4)/FdbR_2c]} \qquad (11)$$

Consideration of the equations given for delivery, power input and efficiency reveals that the relationship between head, power efficiency and delivery for a pump operating at constant speed can be represented as shown in Fig. 5, in the conventional manner.

Corresponding equations for the case of turbulent flow can be written in generalized form as follows:

$$Q = K_1\omega - K_2\sqrt{P_1 - P_2} \qquad (12)$$

$$P_i = C_1(P_1 - P_2)\,\omega + C_2\omega^3 \qquad (13)$$

$$P_0 = Q(K_1\omega - Q)/K_2 \qquad (14)$$

$$E = \frac{QK_2(K_1\omega - Q)}{C_1\omega(K_1\omega - Q) + K^2{}_2C_2\omega^3} \qquad (15)$$

The corresponding graphical representations are shown in Fig. 6 (A), (B) and (C). These curves are in close agreement with Fig. 6 (D), which is plotted from actual performance data.

One significant characteristic of the turbine pump is its power input curve. The power requirement of this type of pump decreases with increasing delivery whereas in the centrifugal pump the power requirement increases with increasing delivery. The rotary positive displacement pump has a power characteristic similar to that of the turbine pump.

The head-delivery characteristics of the turbine pump and rotary pump are identical in general form whereas that of the centrifugal pump shows a curvature in the opposite direction.

Detailed analysis of Equation (11), for the efficiency of the turbine pump, reveals that the form is the same as that of the efficiency equation of the rotary pump. (See "Rotary Pump Theory," W. E. Wilson, *Transactions*, A.S.M.E., May, 1946.) Let

$$A = c^2/6lR_2$$
$$\text{and } B = \pi(R^4{}_1 - R^4{}_0)/dbR_2c$$

then Equation (11) becomes

$$E = \frac{1 - AF}{1 + B/F} \qquad (16)$$

The maximum efficiency will be attained for any given positive displacement pump when the parameter F has the value

$$F = B[\sqrt{1 + (1/AB)} - 1] \qquad (17)$$

The value of the parameter F depends inversely upon the viscosity of the fluid being pumped and consequently will be small when the viscosity is large.

From Equation (17) it is seen that

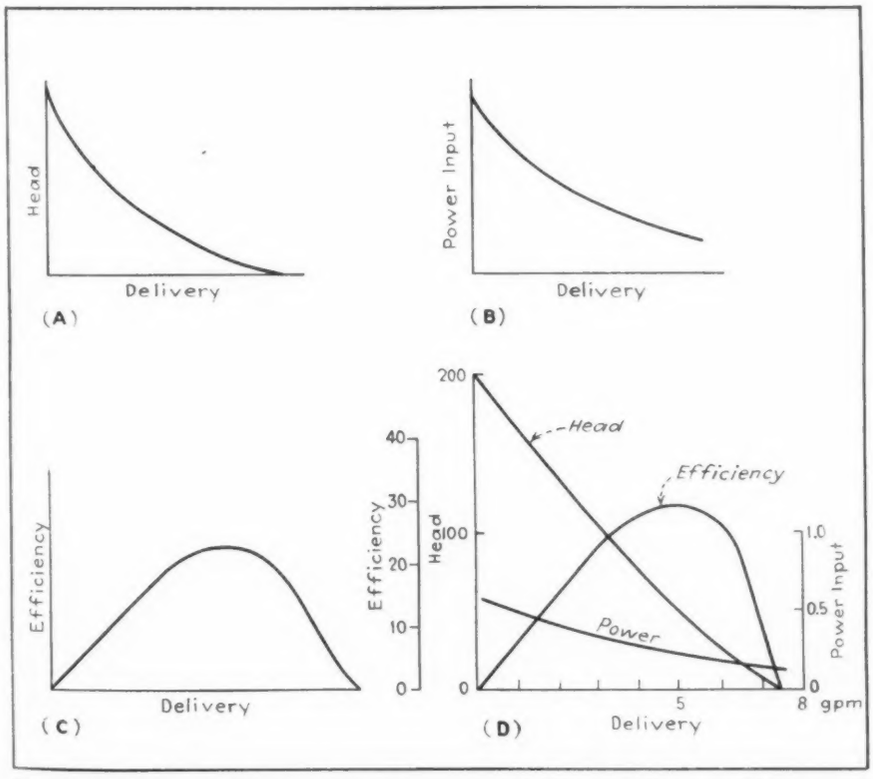


Fig. 6—(A), (B), (C). Theoretical performance characteristics of a turbine pump for turbulent flow, (D). Plot of actual performance showing close agreement.

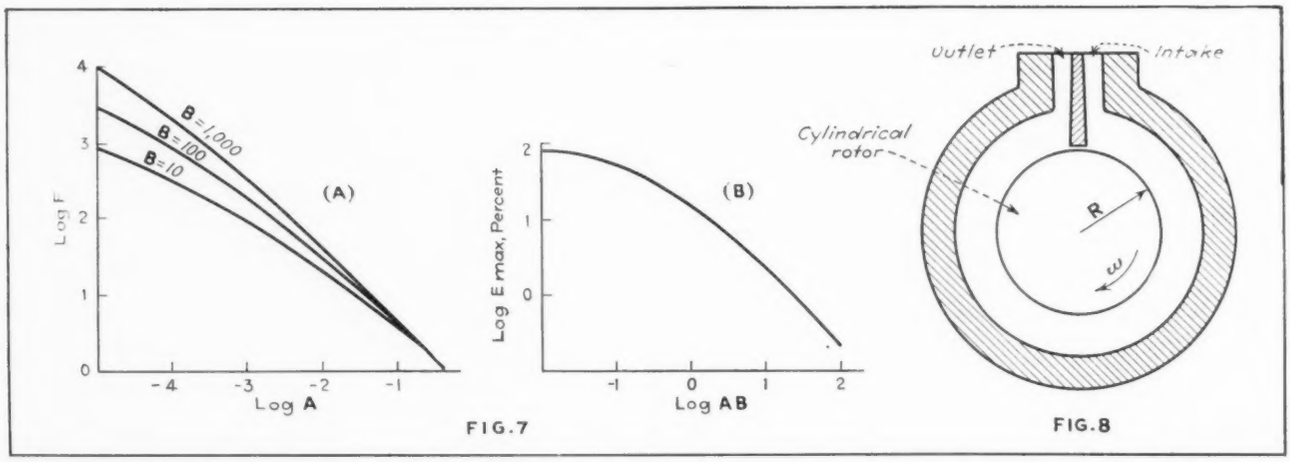


FIG.7 FIG.8

Fig. 7—(A) Values of parameter F. (B) Values of maximum efficiency in terms of dimensionless product. Fig. 8—Simple rotary pump with a plain cylindrical rotor. In this design, intake and discharge passages are separated by a dividing member.

the maximum efficiency E_{max} depends upon the product AB only. This product AB is a dimensionless factor made up of ratios of the various pertinent lengths in the geometry of the pump. Substituting Equation (17) in Equation (16), the expression for the maximum efficiency E_{max} of any pump of the turbine or rotary type is

$$E_{max} = 1+2\,AB\,[1-\sqrt{1+(1/AB)}] \quad (18)$$

The Equations (17) and (18) are represented graphically in Fig. 7(*A*) and (*B*), respectively.

In general, the greater the clearances in a pump the greater will be the value of A and the smaller will be the value of B.

Conventional positive displacement rotary pumps have values of A and B of such magnitudes that maximum efficiencies should exceed 80 percent. But these pumps operate at maximum efficiency with relatively large values of F. If fluids of great viscosity are to be pumped, both the rotary pump and the centrifugal pump fail to handle them with high efficiency. The turbine pump, being essentially a rotary pump with large clearances will operate with fair efficiency when pumping fluids of great viscosity.

The performance of both conventional rotary positive displacement pumps and centrifugal pumps when handling fluids of great viscosity has been studied extensively. It is well known that with these types of pumps it has been impossible to obtain even reasonably high overall efficiencies when handling high viscosity fluids. (See "Influence of Viscosity on Centrifugal Pump Performance," A. T. Ippen, Paper No. A45-57 A.S.M.E.)

On the basis of the foregoing analysis it can be shown that a simple type of rotary pump, known as the viscosity pump, will pump fluid of any viscosity with a theoretical peak efficiency of 33-1/3 percent. This pump consists of a plain cylindrical rotor revolving in a housing with a cylindrical interior surface as shown in Fig. 8. The intake and discharge passages are separated by a dividing member.

As the cylindrical rotor revolves it transports the fluid from inlet to discharge part by shearing action. The pressure difference between inlet and outlet causes a flow from discharge to inlet side. If the speed of rotation and viscosity are great enough a net flow from inlet to discharge can be maintained. While the peak theoretical efficiency of such a pump is 33-1/3 percent, it does exceed the efficiency of centrifugal and conventional rotary pumps when pumping very viscous fluids.

The turbine pump closely resembles this simple viscosity pump and will operate with comparable efficiency under similar conditions. For example, if the ratios of dimensions of a turbine pump are

$R_1/R_2 = 0.6$ $\quad d/R_2 = 0.01$
$R_0/R_2 = 0.2$ $\quad b/R_2 = 0.75$
$c/R_2 = 0.15$ $\quad l/R_2 = 2\pi$

the resulting maximum theoretical efficiency when pumping viscous liquids is 40 percent. But the ratio d/R_2 is rather larger than is ordinarily encountered in such pumps. If the ratio d/R_2 equals 1/1,000 rather than 1/100 the theoretical overall efficiency would be 10 percent.

In conclusion the principal developments brought forth are: (1) The turbine pump functions as a rotary positive displacement pump with large clearances or a viscosity pump. (2) Any given turbine pump when operating in the laminar range has a definite maximum efficiency that is attained at a specific value of the parameter $(P_1-P_2)/\mu\omega$ (3) Turbine pumps promise satisfactory operation if used to pump very viscous fluids against relatively low heads.

* * * *

THE INVENTOR OF THE COTTON GIN, Eli Whitney, was also the originator of the system of interchangeability of mechanical parts. In 1798 he was commissioned by the United States Government to manufacture 15,000 muskets. He spent a full year designing and building the machinery he needed, but the governmental officials demanded muskets rather than ideas and promises. Whitney took enough parts for ten muskets to the capital. Here he assembled ten muskets in front of the amazed officials, and this one demonstration was enough to quiet the officials and to impress them with the desirability of having interchangeable parts. From that time on all government contracts let for muskets contained a clause stipulating that parts should be interchangeable.

NEW BOOKS

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In general, the 34 chapters present in order, (1) the fundamentals of resistance welding, (2) the nature of the different resistance welding processes, (3) the resistance welding characteristics of various important metal groups and how these characteristics affect welding procedures, (4) recommended practices for resistance welding, (5) mechanical and electrical characteristis of welding machines, (6) inspection, testing, and quality control, and (7) maintenance of equipment. An appendix lists definitions, symbols, and tables.

The Chemistry and Technology Of Plastics

Raymond Nauth. 522 *pages.* 6¼ *x* 9¼ *in., green clothboard covers. Published by Reinhold Publishing Corp.,* 330 *W.* 42*nd St., New York* 18, *N. Y. Price* $9.50.

This volume is useful to engineers seeking background information in the field of plastics. History, properties and applications of thermoplastic and thermosetting resins as well as synthetic rubber, natural resins and plywood, are described. Mold design, presses, and related equipment, are also covered.

Directory of Member Institutions And Review of Current Research —1947

Compiled by John I. Matill, Secretary, Engineering College Research Council. 103 *pages,* 6 *x* 9 *in. Published by the Engineering College Research Council, College of Engineering, State University of Iowa, Iowa City, Iowa.* $1.

This directory lists the member institutions of the Engineering College Research Council of the American Society for Engineering Education with complete addresses. The departments and laboratories engaged in research are listed for each institution. The names of the director and officers of the research activities are included. A short paragraph describes the research policies of the members. The number of personnel, actively working on research, is noted in addition to the expenditures for research during the past year. The listed research projects: Recently completed, presently active and anticipated for the near future, give a concise picture of the work being done by each member institution.

The official representatives of the member institutions are listed in the last ten pages with the by-laws that govern the Council.

Applied Mathematics For Engineers and Physicists

Louis A. Pipes. 618 *pages,* 6 x 9 *in., red clothboard covers. Published by McGraw-Hill Book Company, Inc.,* 330 *W.* 42*nd Street, New York* 18, *N. Y. Price* $5.50.

This textbook is designed to acquaint graduate students in engineering and physics with the mathematical methods used in solving technical problems. The book also fills the demand for a treatise on advanced mathematics that has appeared in engineering and physics as a result of close collaboration of theory and experiment in industrial research laboratories.

The material dealt with is general in nature and includes the fields of electrical, mechanical, and civil engineering as well as the mathematics of classical physics. The mathematics of mechanical and electrical oscillations, electrical field theory, modern operational calculus, nonlinear oscillations, and potential field theory is clearly set forth.

Resistance of Materials

Fred B. Seely, *Prof. of Theoretical and Applied Mechanics, University of Illinois. Third Edition,* 486 *pages,* 5 x 8½ *in., clothboard covers. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y. Price* $4.

In the third edition, as in the previous editions, the aim is to emphasize the engineering significance of the subject of mechanics of materials. Changes in the third edition include the treatment of lightweight metals, such as aluminum and magnesium, and of plastics, which have become more widely used as load-resisting members during the last twelve years.

Likewise consideration is given to the wider use of high strength metals, of welded connections, of processes such as shot peening and cold rolling to introduce residual surface stresses, and similar developments. The third edition, like the second, is divided into two parts. Part I consists of the more elementary parts of the subject. Each chapter in Part II is independent of the others so that any chapter of this part can be studied after the main portion of Part I has been completed. Many new problems and new figures have been added.

Radiography in Modern Industry

First edition, 122 *pages,* 8¾ *x* ½ *in. Compiled and published by X-Ray Division, Eastman Kodak Company, Rochester* 4, *N. Y.* $3.

A test of fundamental knowledge for industrial radiographic practice directed at the professional worker and student of radiography.

The 16 chapters include discussion of radiography's function, process, x-ray generators, geometric principles, exposure, scattered radiation, sensitivity, special techniques, films, processing room, and safety.

Modern Plastics Encyclopedia

Published by the Plastics Catalogue Corporation, 122 *E.* 42*nd St., New York* 17, *N. Y. Eleventh Edition. Three volumes,* 9 x 12 *in.,* 1,556 *pages. Price* $8.50.

The 1947 Modern Plastics Encyclopedia contains information on plastics materials, their processing and their applications. The introductory pages reflect how extensively plastics are being used in everyday products. Photographs of the important applications in each field reveal the extensive penetration of plastics into consumer and industrial products.

Volume I is a reference to recent developments and applications for all types of materials, coatings, films, fibers, fabrics, laminates, and resin-woods. Included for the first time is a selected bibliography on German plastics. Also assembled is comprehensive information on optical properties of plastics. Volume II is devoted to processing problems. Engineering design, construction design, molding, extruding, casting, fabricating, finishing and assembly are covered. Latest developments in machinery are described, plant layouts are suggested, and molding plant and tool room equipment is discussed. Volume III is devoted entirely to ten special charts. Two new charts are on laminating resins and properties of synthetic fibers. Charts of plastics identification, chemical formulae, plasticizers, plastics properties, solvents, adhesives, coatings, synthetic rubbers properties have all been brought up to date.

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With a new Ozalid Streamliner you do jobs far beyond the scope of any other reproduction process.

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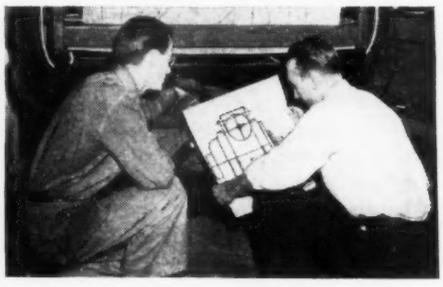
You have a choice of 10 types of prints instead of 1 because OZALID employs a DRY DEVELOPMENT technique which greatly simplifies printmaking . . . permits use of a variety of sensitized papers, cloths, foils, and films—all of which you process exactly the same, in seconds.

Here are the ten Ozalid "types" and some ways in which you'll save time, labor, and material by using them:

1. OZALID BLACK-LINE

2. OZALID BLUE-LINE

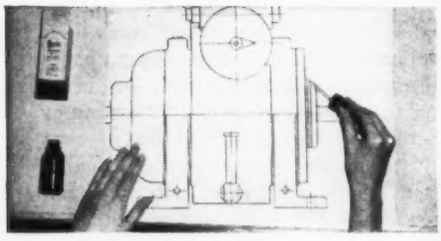
3. OZALID RED-LINE



For routine prints in the drafting room, shop, or office.

Anything drawn, typed, or printed on translucent material is reproduced with sharp, easy-to-read images on a white background.

By assigning identifying colors, you can distinguish prints of different departments... recognize checked from unchecked prints, etc.

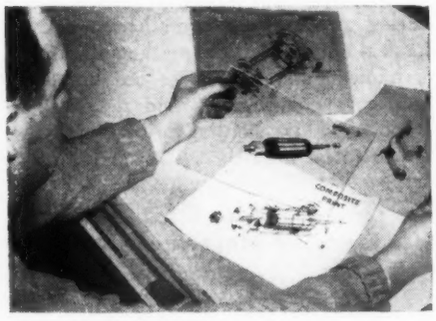


4. OZALID SEPIA-LINE

5. OZALID DOUBLE-COATED SEPIA

6. OZALID TRANSLUCENT CLOTH

For "intermediates" which may be substituted for originals in subsequent print production. Important savings in time and labor are realized when design changes are necessary: Obsolete lines are removed with Ozalid Corrector Fluid; changes drawn in and required number of prints made from "new" masters.



7. OZALID FOIL

For composite prints: Details are printed on individual foils . . . and overlaid to produce a print showing separate details in relation to each other.

Ozalid Foil also produces faster-printing intermediates from old or worn originals, since it intensifies line detail.

8. OZALID CHARTFILM

For lustrous black-line reproductions on white plastic base, ideal for wiring diagrams, instrument panels, etc. No protective covering is needed; can be cleaned with a damp cloth.

9. OZALID OPAQUE CLOTH

For extremely durable prints for shop use, files, etc.

10. OZALID DRYPHOTO

For almost instantaneous, high-quality reproductions of any photographic subject—in sepia, black, blue, or two-tone effect.

Produce them from film positives (as illustrated above), which can be made from any of your negatives. Keep on file. Use when desired.

Gentlemen: **Dept. 336**

Please send free Ozalid Streamliner booklet 322and the 10 types of Ozalid prints.

Name_____

Position_____

Company_____

Address_____

OZALID

Division of
General Aniline and Film Corporation
Johnson City, New York
Ozalid in Canada
Hughes Owens Co., Ltd., Montreal

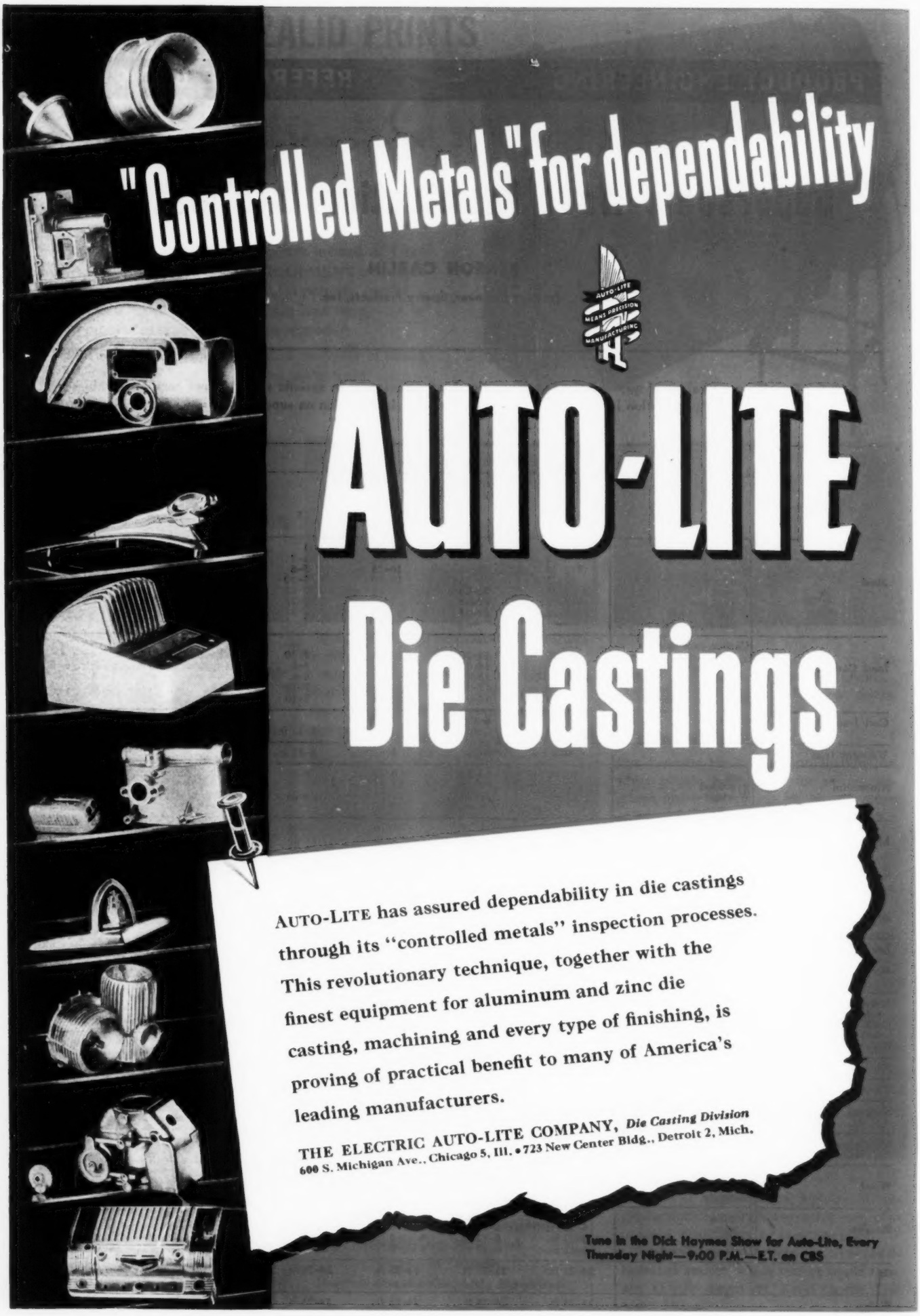
Supersonic Wave Penetration into Materials

BENSON CARLIN

Product Engineer, Sperry Products, Inc.

Note—Experimental values of approximate maximum depth of penetration in specific samples; not computed values nor absolute indication of penetration in any single material. For other information on supersonic testing see article page 113

Type Material		Range is in feet unless otherwise marked				Remarks
		Testing Frequency, Megacycles				
		0.5	1	2.25	5	
Steel	Ingots	4–6	2–4	1–2	1	Generally, depth of penetration into steel depends on the amount of working and processing of the material. Finer grain structure usually permits greater penetration.
	Billets, blooms	5–12	6–8	3–4	1–2	
	Rolled	22–25	22–25	10–25	5–8	
	Cold drawn	22–25	22–25	16–20	7–10	
	Forged	22–25	22–25	22–25	22–25	
	Tool steels	22–25	22–25	22–25	22–25	
	Spring steels	22–25	22–25	22–25	22–25	
	Stainless steels	—	—	—	—	
Steel Castings	Carbon cast steels					Cast steels in the lower carbon range permit greater supersonic penetration.
	Low carbon	15–20	15–20	10–15	7–10	
	Med. carbon	14–18	14–18	8–12	5–8	
	High carbon	13–16	13–16	7–10	4–6	
	Low alloy castings	17–20	17–20	12–15	7–10	
	High alloy castings	17–20	17–20	12–15	7–10	
Cast Iron	Gray iron	1–2	6–12 in.	2–4 in.		"Scattering" of supersonic vibrations results where excessive porosity exists.
	Malleable	7–10	7–10	3–5	6–12 in.	
Wrought Iron		7–10	7–10	3–5	6–12 in.	
Aluminum	Cast	12–15	12–15	8–10	8–10	Coarse structure or porosity will interfere with penetration. Finer grain structure permits greater penetration.
	Extruded	22–25	22–25	22–25	22–25	
	Worked	22–25	22–25	22–25	22–25	
Magnesium	Cast	12–15	12–15	8–10	8–10	Physical properties similar to aluminum.
	Extruded	22–25	22–25	22–25	22–25	
	Worked	22–25	22–25	22–25	22–25	
Copper	Cast	—	—	—	—	Coarse grain structure disperses vibrations.
	Worked	0–6 in.	0–12 in.	—	—	
Brass and Bronze	Cast, fine grain	0–1½	0–1½	—	—	Heat treatment will substantially extend limits of penetration.
	Cast, coarse grain	—	—	—	—	
	Worked	1–5	1–3	—	—	
Lead		—	—	—	—	Physical properties absorb vibration.
Nickel	Cast	1–3	1–3	1–2	6–12 in.	Greater porosity is usually present in cast materials.
	Worked	1–15	8–10	5–8	3–5	
Monel — Worked		10–15	8–10	5–8	3–5	
Gold — Worked		0–1	0–1	—	—	Testing experience very limited.
Silver — Worked		5–10	2–5	1–2	0–1	Application usually confined to small pieces.
Platinum		7–10	7–10	3–5	3–5	Figures are relative penetration. Sizes tested were not in this range.
Tungsten		7–10	7–10	3–5	3–5	
Sintered Carbides		0–12 in.	0–6 in.	0–3 in.	0–3 in.	Most of testing done at high frequencies because of nature of flaws to be found.
Molybdenum	Sintered	5–10	5–10	1–5	0–2	
	Worked	21–25	21–25	21–25	15–18	
Wood	Hard	0–8 in.	0–4 in.	—	—	Direction of grain and amount of moisture in the wood affects transmission into medium.
	Soft	—	—	—	—	
	Masonite	0–8 in.	0–4 in.	—	—	
Plastics	Vinylite	6–12 in.	6–12 in.	6 in.–6 ft.	6 in.–6 ft.	Depends on amount of filler in material.
	Catalin	6–12 in.	6–12 in.	6 in.–6 ft.	6 in.–6 ft.	
	Bakelite	6–12 in.	6–12 in.	6 in.–6 ft.	6 in.–6 ft.	
	Lucite, or Plexiglas	6–12 in.	6–12 in.	6 in.–6 ft.	6 in.–6 ft.	
Oil		24–25 ft.	24–25 ft.	24–25 ft.	24–25 ft.	Indication of penetration limited only by capabilities of instrument.
Water		24–25 ft.	24–25 ft.	24–25 ft.	24–25 ft.	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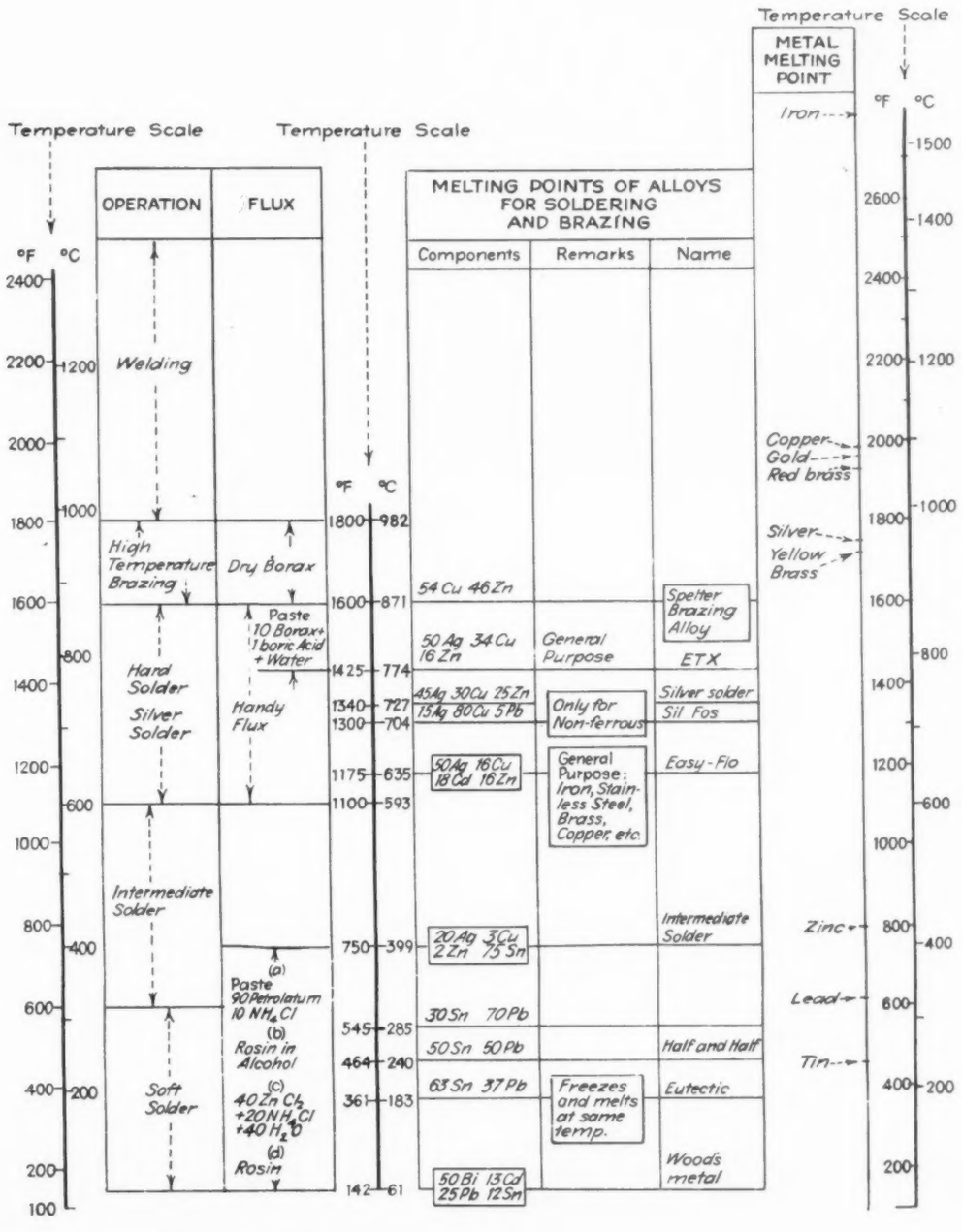
Temperature Chart For Soldering, Brazing and Welding Processes

RICHARD C. HITCHCOCK
State Teachers College, Indiana, Pa.

DESIGN ENGINEERS are frequently faced with the problem of specifying methods and materials to be used in joining component parts. Since the methods used are strictly allied with production techniques, the designer may not always have sufficient information on which to base his decision. This chart has been prepared to provide, in a convenient form, the melting points and components of various common soldering and brazing alloys. Melting points of some pure metals are shown at the right. The temperature limits of various joining processes are indicated with the type and composition of the flux best suited for the process. Three pairs of identical Fahrenheit and Centigrade temperature scales are shown with the low values at the bottom of the chart. The chart is a compilation of present good practice and does not indicate that the processes and materials cannot be used in other ways under special conditions.



Corrosion-resistance, beauty and high strength are the best-known advantages of ARMCO Stainless Steels, but their ability to endure high temperatures for long periods is of equal or greater importance in many applications.

Special stainless heat-resisting grades are often the most economical metals to use when varying or constant temperatures exceed 1600° F. Creep strengths are high and rates of oxidation low. In many cases the ultimate performance cost is low compared with less resistant materials that require frequent repairs or replacement.

ARMCO 27 Stainless Steel, for example, withstands destructive scaling in intermittent operations at 2000° F.

TWO OF MANY CASES

In one plant daily production of malleable castings increased from 12 to 24 tons *in the same furnace* when a stand of bulky cast boxes (1800 pounds) was replaced by lighter stainless steel boxes (580 pounds).

An ARMCO Stainless Steel experimental muffler on a large transcontinental bus has been in service more than 100,000 miles. It shows no ill effects from exposure to heat and corrosive gases.

Your oxidation problem may range all the way from annealing furnace covers to truck or Diesel mufflers. Write for technical data on ARMCO Heat-Resisting Stainless Steels. They are produced in sheets, strip, plates, bars and wire. Just address The American Rolling Mill Company, 322 Curtis St., Middletown, Ohio.

ARMCO

ARMCO STAINLESS STEEL

NEW MATERIALS AND PARTS

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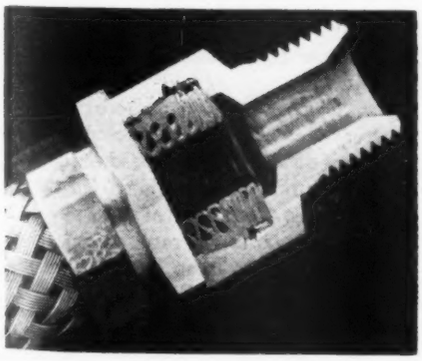
Flexible Metal Hose

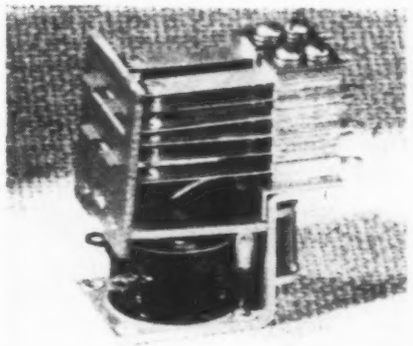
The Brockway Co., Naugatuck, Conn. Seamless flexible metal hose, made of a special alloy seamless bronze tube, is fabricated by an unusual method. The tube is gently but firmly formed into a uniform helically corrugated, flexible hose, retaining the maximum desirable characteristics of the original hose. Because the hose is not work-hardened in its formation, it is not brittle. The hose is incased in a high-tensile bronze wire braid. This protective sheath is permanently attached to couplings and relieves the hose of damaging strains. The fitting provides a metal-to-metal seat because of the seal produced between the fitting body and the spring washer effect of the hose. No brazing or packing is required.



Multipole Relays

Leach Relay Co., 5915 Avalon Blvd., Los Angeles 5, Cal.

These small relays with versatile arrangement of contact systems are capable of handling most control circuits

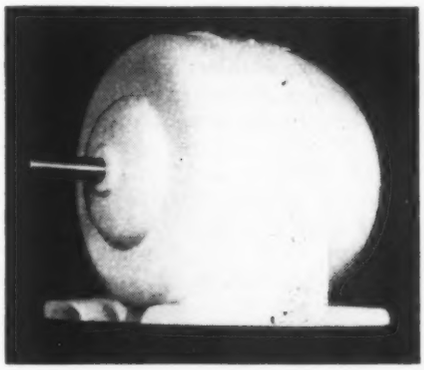


where currents do not exceed 12½ amp at 115 v a-c, non-inductive. The contact stack can be furnished with make-before-break or with single or double-throw action, supplied either singly or in combination up to a maximum four-pole double-throw. These small relays, 1 x 1⅞ x 1½ in., can be fitted with ⅛ or ¼ in. fine silver contacts. Coils can be furnished for shunt, series, a-c or d-c operation.

Lightweight Motors

Electra-Motors, Inc., 1110 N. Lemon St., Anaheim, Cal.

Built with high tensile strength heat-treated alloy aluminum motor frames, these fractional horsepower motors have reduced weight about 50 percent. The ½ hp motor weighs 19½ pounds. Bearings can be precisely located because of the one-piece load-bearing frame. The rotor is molded from pure aluminum. The insulated windings are moisture resistant. Both stator and rotor cores are easily accessible. Positive ventilation is provided by the

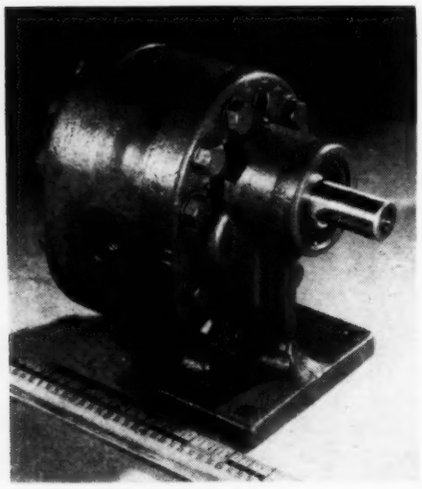


"Temp Trol" design—with vents in the under side of the housing. This motor can be operated both vertically and horizontally. The Electra-Motor is of the continuous duty, drip proof type, 3 phase, 60 cycle, 220/440 volts. This motor is available in ¼, ⅓, ½ and ¾ hp sizes.

Hydraulic Gear Pumps

Hydro-Power Inc., Springfield, Ohio

The Cut-line gear pumps operate equally efficiently in either direction. Floating bronze wear plates at either side of the gears divide clearance into four narrow slits, thus providing high frictional resistance to flow recircula-

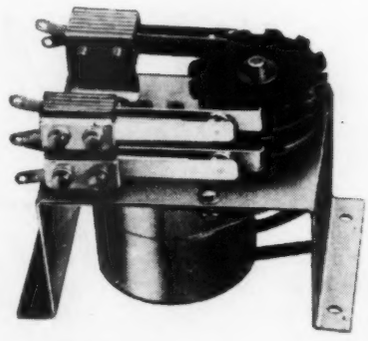


tion. A small, built-in valve directs slippage oil past the shaft needle bearings for positive, continuous lubrication. Shafts are alloy steel, hardened and ground; cases are cast from alloy iron. The pumps are dimensioned so that discharge can be piped at full flow from either front or side, and the shaft has a rotary-type seal. These pumps are available in 10, 15 and 20 gpm capacities with over-all efficiencies of 90 to 92 percent.

Time Controller

The R. W. Cramer Co. Inc., Centerbrook, Conn.

Model VF Timers were designed to be built into automatic vending machines, dish washing machines, automatic laundry machines, and other types of equipment requiring time and sequence control. The timers are equipped with Cramer Synchronous Motors Type SX. They are available with a variety of speeds from 1 rpm to 1/24 revolution per hour. The overall width of the timer is approximately 2½ in. with a length of 3⅝ in.; height varies from 2½ in. for a single cam unit to 3⅝ in. for six cam units. The timers are avail-



able to control from one to six circuits for 6, 24, 110 and 220 V, 50 or 60 cycle current. Contacts have a 10 amp rating and can be supplied in single or double throw types. Dependent on the application, the contacts are either of the slow make or break, or snap action type.

Phosphorescent Sheeting

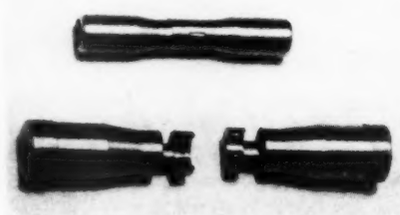
E. I. DuPont de Nemours & Co. Inc., Wilmington 98, Del.

Phosphorescent "Lucite" acrylic resin sheeting is now available in commercial quantities. This luminescent form of the plastic contains pigments that cause the material to glow for a period up to 12 hr. after exposure to ordinary light. This form of the plastic has all the advantages of the standard form in wear and weather-resistance. It should be useful in both indoor and outdoor applications where continuous lighting is desirable but where the maintenance of a power supply is not feasible. The material should find use as a decorative trim and as location indicators.

Cable Disconnects

Potter Aeronautical Co., 85-87 Academy St., Newark 2, N. J.

Originally designed for use with aircraft engine control cables, these disconnects can be used for any control cables that operate inside a tube. These disconnects are used with push-pull control cables but have been designed so that applied torque will not separate the two components. The ears of the inclosing arcs pass the centerline of the meshing piece so that torque tightens the junction. This reduces scarring

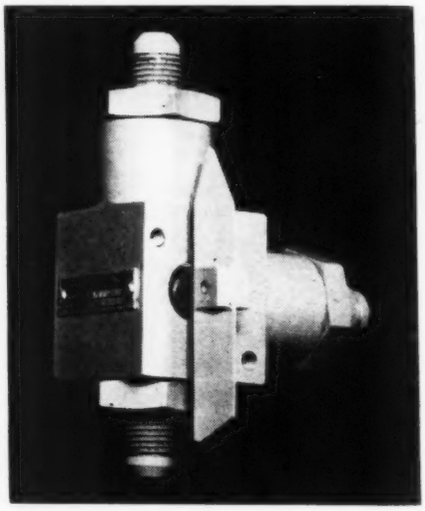


action on the internal surface of the cable tube. These disconnects are available to fit all sizes of cables, and can be machined for any type of connection to the cables.

Full Tank Selector Valve

Electrol Inc., 85 Grand St., Kingston, N. Y.

While developed primarily for control of aircraft fuel systems, this positive-position positive-sealing selector valve, Model 544, has industrial fuel supply applications. It is usable in air, water and oil, as well as in gasoline systems. This valve assures positive positions of



the control handle through built-in detents. The poppet-type valve eliminates sticking. The unit has low pressure drops and the connecting fittings are integral. There are four handle positions: Tank No. 1 "on", both tanks "on", tank No. 2 "on" and both tanks "off". The housing is made of aluminum alloy with anodized finish. Port sizes can be varied to fit individual specifications.

Variable Speed Transmission

Lombard Governor Corp., Ashland, Mass.

For use where the ratio of maximum to minimum output speed is high, this wide range transmission unit will give continuously adjustable output speed from a constant speed motor power source. Between the input and output shafts is a planetary speed reducing unit. The output speed is varied by an adjustable speed-control belt that changes the rotation rate of the ring gear. This control can be operated directly or remotely. The gears are of heat-treated helically cut alloy steel and the worm and ring gears are cen-

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Johnson Bronze Sleeve Bearings Give You Every Worthwhile Advantage

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- QUIET
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- UNIT CONSTRUCTION
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- CONFORMABILITY
- NATION WIDE SERVICE

Are you buying more bearing than you need? Are you building sales resistance into your product by making it too complicated? One of the easiest ways to simplify the design and operation of a motive unit . . . without sacrificing performance or efficiency . . . is to install Johnson Sleeve Bearings.

The adoption of Sleeve Bearings brings many worthwhile advantages. It gives the designer more freedom in tolerances. It simplifies installation, also maintenance and replacement. The solid bearing surface provides excellent load carrying capacity. This bearing surface permits a continuous film of lubricant to form between the bearing and shaft . . . preventing wear, eliminating noise and reducing friction to the minimum.

Johnson Sleeve Bearings are more economical too. Their low unit cost provides manufacturers with a much lower cost and a greater profit on each model. They are precision made . . . of highest quality materials. Why not investigate the possibilities of using Johnson Sleeve Bearings in your product? We can give you sound advice and excellent delivery—NOW.

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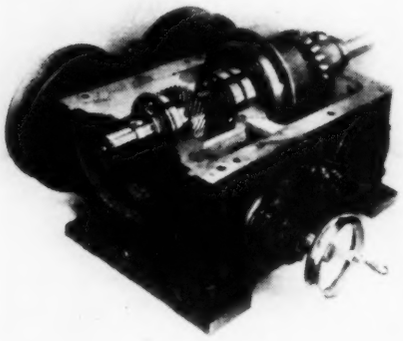
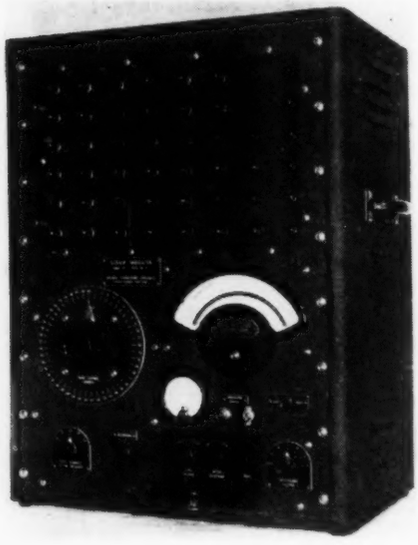


trifugally cast bronze. All gearing is totally inclosed and immersed in oil. Ball bearings are used throughout. Nine different models transmit 2 to 15 hp from motors of various speeds and types. Useful speed range of greater than 20 to 1 is obtained with a minimum speed of approximately zero.

Strain Measuring Equipment

Nosker Engineering Products, Yellow Springs, Ohio

The Model 2A Strain Indicator is a portable, direct-reading, electronic instrument for measuring static strain, selectively, from as many as 48 wire-strip strain gages. Channels are selected by manually operated switch. The strain is read directly on the illuminated gage. Cables with connectors are supplied for rapid connection of gages. All the necessary automatic switching circuits are included in this unit so that as many as 10 indicators can be connected to a single Model 4 Strain Recorder. This unit, not illustrated, will give an ink-on-paper recording of as many as 480 channels at the rate of three channels per second. The Strain Indicator is housed in a metal cabinet 21 in. wide, 28 in. high and 13½ in .deep. It weighs about 125 pounds. The Strain Recorder is mounted in a similar cabinet 21 in. wide, 19¼ in. high and 13½ in. deep. It weighs approximately 110 pounds.



Electronic Analyser

Weston Electrical Instrument Co., Newark 5, N. J.

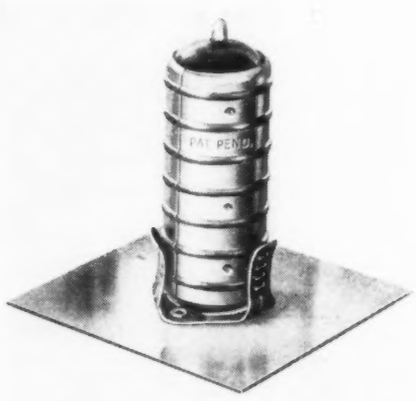
Providing in one instrument the functions of several instruments with no sacrifice in accuracy, the Model 769 is a general service unit It can be used as a standard analyzer, requiring no external power. Six 10,000 ohm per volt d-c voltage ranges, six rectifier type a-c voltage ranges, three ohmmeter

ranges and six d-c current ranges can be used without external power. Using 115 v, 60 cycle external power, Model 769 is a high impedance electronic volt-ohmmeter in which all voltmeter and ohmmeter ranges are completely stable. This unit can also be used as a stable, probe type, vacuum tube voltmeter, for use to 300 megacycles. An RF probe, fabricated from bakelite and polystyrene, has a minimum metallic area and measures high frequency potentials in congested areas. A special d-c probe, containing a 3 megohm isolating resistor, is furnished for measuring d-c potentials in the presence of RF, AF or AC voltages. Overall measurements of the Model 769 are: 10 x 13 x 6⅛ in., and the unit weighs 13½ pounds.

Flexible Tube Shield

Staver Mfg. Co., 33-21 85th St., Jackson Heights, N. Y.

Known as Mini-Shields, these flexible shields for miniature tubes are made of tin, terne plate or aluminum. They are made in three lengths: short intermediate and long, and are designed to fit the smallest diameter tubes. A ¼ in. overlap allows expansion so that the shield can be used with larger



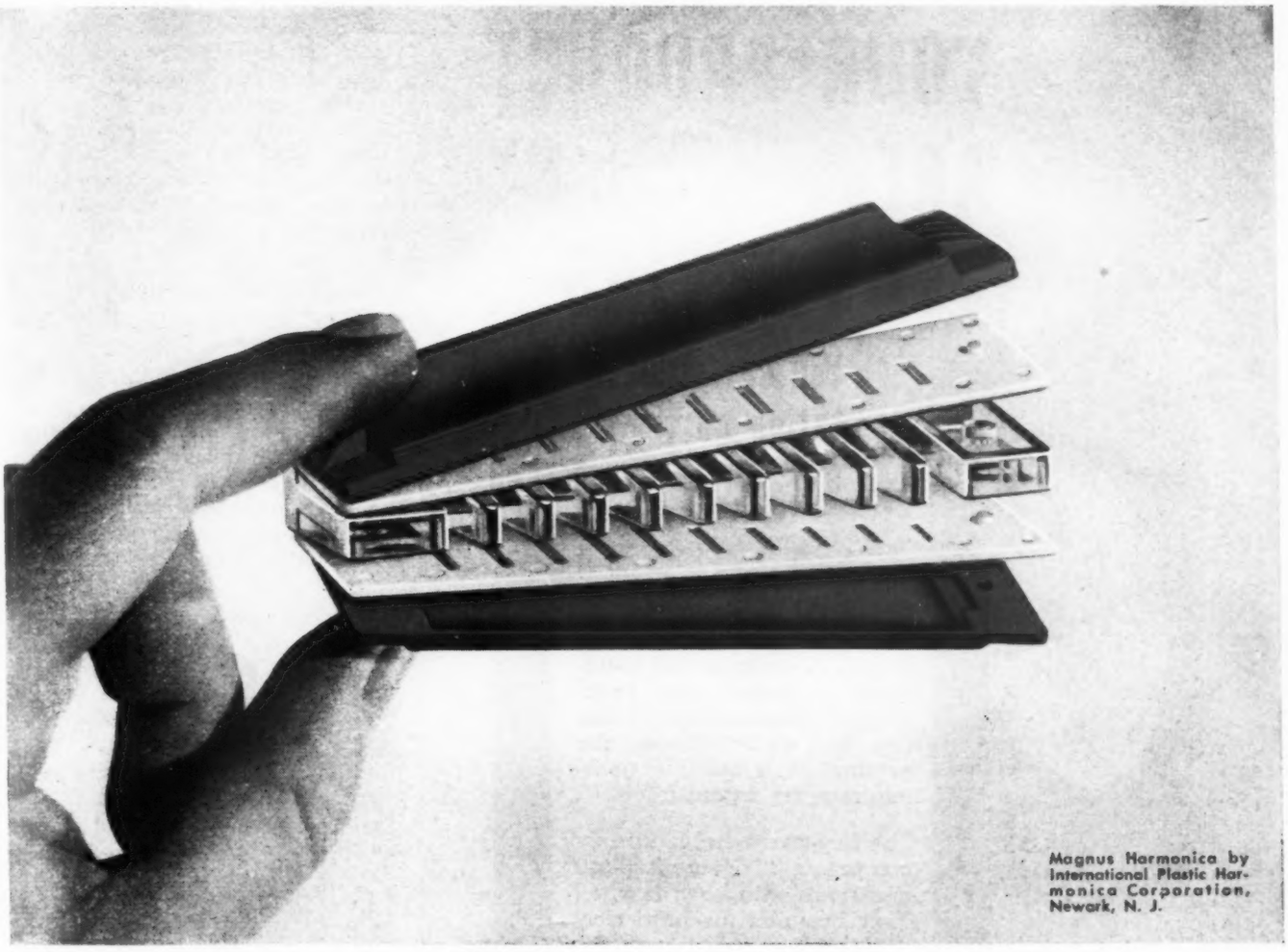
tubes. Three rows of dimples on the shield maintain contact with the tube and prevent vibration or rattling. These dimples also insure a free air space to cool the tube. Shields are available with blackened inner surfaces, maintaining lowest operating temperatures.

True Profile Instruments

Physicists Research Co., 321 S. Main St., Ann Arbor, Mich.

A mechanical-electronic instrument that provides a magnified chart record of the shape, height and spacing of surface irregularities, the Proficorder will show the true profile of most machined and finished surfaces. It is highly flexible as to the amount of detail recorded, and it permits tracing widely varied surfaces at the same magnification. The Proficorder is designed to show waviness, bows, steps and other surface irregularities spaced approximately 1/32 in. apart. In machining and grinding applications, the primary function of this instrument is to show irregularities caused by the machine or set-up used to produce the surface, rather than to show roughness caused by the cutting action of the tool or

"This advertising message, appearing in 4-color cover position in NEWSWEEK, BUSINESS WEEK and U. S. NEWS, is developing business for Monsanto Lustron molders and fabricators."



Magnus Harmonica by International Plastic Harmonica Corporation, Newark, N. J.

5 parts with Lustron —instead of 80

A MONSANTO PLASTIC

With Lustron, Monsanto's polystyrene, this harmonica manufacturer gets a long lead and more profit in a big market. Formerly, each harmonica was assembled from 80 parts, requiring 150 operations. Today, with Lustron, a better product is produced . . . *with only 5 parts, assembled in just 15 seconds, with 7 operations.*

Moreover, Lustron molds speedily in the fastest mass production techniques. Light weight plus low cost per pound gives more items per material dollar. Expensive finishing operations are eliminated. All waste is salvageable at full value. Monsanto Lustron offers a rainbow range of sales appealing colors—clear and opaque. It has low temperature strength, high dimensional stability, excellent resistance to alkalies, acids and water.

Let Monsanto plastics engineers show you how to speed products to market with more profits, via Lustron. Write: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Mass. In Canada: Monsanto (Canada) Limited, Montreal.

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The broad and versatile family of Monsanto Plastics includes: Lustron* polystyrenes • Cerex* heat resistant thermoplastics • Vinyls • Nitron* cellulose nitrates • Fibestos* cellulose acetates • Thalid* resin • Resinox* phenolics • Resimene* melamines • Forms in which they are supplied include: Sheets • Rods • Tubes • Molding Compounds • Industrial Resins • Coating Compounds • Continuous Films • Vuepak* rigid, transparent packaging materials. Saflex* safety glass interlayers.

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IF THE GEARS IN YOUR PRODUCT ARE *custom-cut* BY PERKINS...

You can stake its reputation on its trouble-free power transmission

● **Great as the demand has been . . . large as the quantities produced have been, Perkins Custom-Cut Gears are, first and foremost, the product of a reliable gear-engineering organization.**

The key-personnel is largely composed of New England craftsmen who have learned their business the hard way — through experience in the shop as well as appropriate schools. While we by no means wish to imply that the men at our disposal constitute a monopoly of the country's gear engineering brains, we do believe that we are capable of producing custom-cut gears which will stand up well under any comparative test.

● **PERKINS MAKES — In All Materials, Metallic & Non-Metallic** Helical Gears, Bevel Gears, Ratchets, Worm Gears, Spiral Gears, Spur Gears, Ground Thread Worms

PERKINS MACHINE & GEAR Company

Springfield 2, Massachusetts

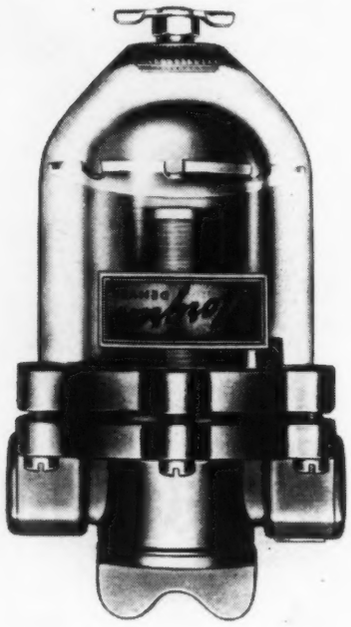
You Furnish the Specifications
•
We'll Produce the Gears!

wheel. The Proficorder consists of a Tracer with diamond point, a Piloting Fixture with motor-driven slide for moving the Tracer and an Amplicorder unit that includes: an amplifier, the chart recording mechanism and the control panel. Various Tracers and Piloting Fixtures provide for profiling flat or cylindrical surfaces, external or internal, and remote portions of large surfaces. Maximum length of trace is approximately 2 inches.

Plastic Bowl Air Filter

The C. A. Norgren Co., 222 Santa Fe Drive, Denver 9, Colo.

Centrifugal force is used to separate oil emulsion and moisture from compressed air lines in this filter. Solid impurities are removed from the air by a 200 mesh, reinforced Monel wire screen. A double right angle air inlet sets the air swirling and throws the moisture and oil emulsion against the wall of the



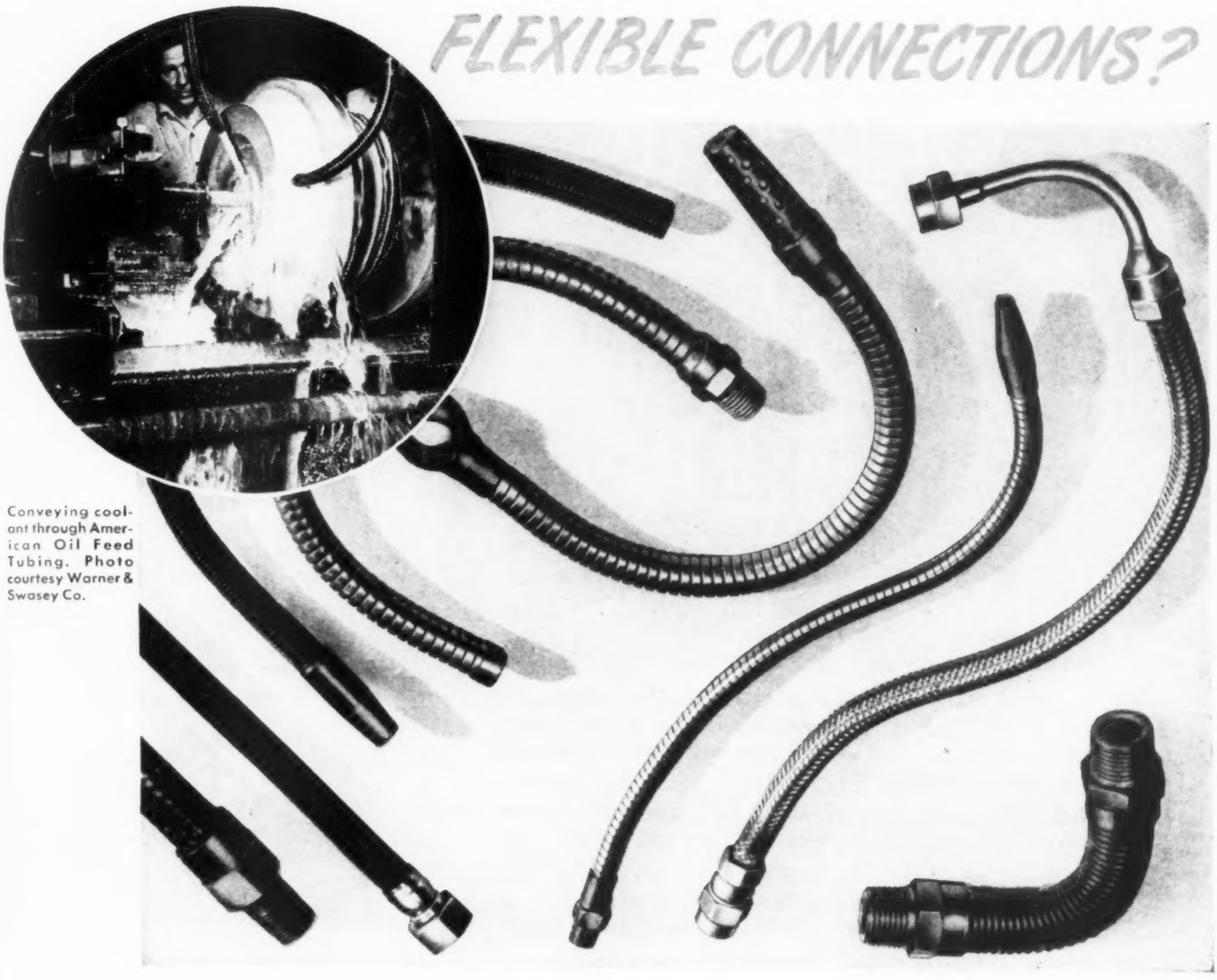
bowl. The liquids collect on the walls and run down into a quiet zone below the baffle plate. The thin plastic baffle prevents the separated liquids from being driven along with the air. The operator can see when the lower part has accumulated sufficient liquid to warrant draining the filter through the bottom cock. These filters are available in ¼, ⅜ and ½ in. iron pipe sizes. All parts, except the body, are interchangeable between sizes.

Power-Factor Capacitors

General Electric Co., Schenectady 5, N. Y.

Power-factor capacitors, made of cast glass bushings with integral hardware, can be hermetically sealed. The bushings are made of exceptionally stable,

FLEXIBLE CONNECTIONS?



Conveying coolant through American Oil Feed Tubing. Photo courtesy Warner & Swasey Co.

...just give AMERICAN the Specifications

ABOVE are samples of special flexible metal connectors, tailor-made by American with end fittings attached. Such assemblies simplify the job of design and production departments throughout industry.

Available in brass, bronze, aluminum, steel and other metals, in sizes ⅛″ to 12″ I.D., American Metal Hose is manufactured from strip in four spirally wound types. American Seamless Flexible Metal Tubing, flexible as garden hose and as leakproof as the seamless bronze tube from which it is made, is standard in sizes ⅛″ to 4″ I.D.

Whether your problem is one of vibration, misalignment, connecting moving parts or piping in cramped spaces, if it involves conveying steam, oil, water and other liquids, semi-solids or gases, look to American Flexible Metal Hose or Tubing for an economical solution. Write for literature, and feel free at any time to consult our Technical Department. 47297

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METAL HOSE

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3. Nickeloid Metals may be worked and fabricated — with reasonable precaution and skill — without injury to their highly polished surfaces, the same as most basic metals.
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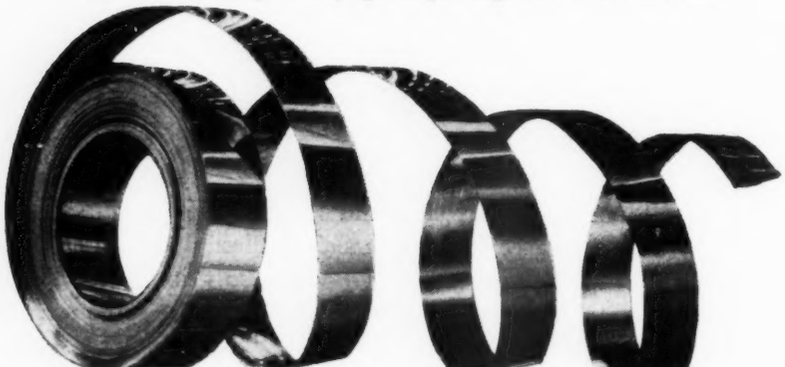

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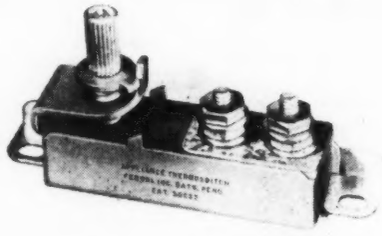
ical properties. The second section discusses the six classes of plastics, devoting a chapter to each major group. The third section covers commercial methods used in the manufacture of plastics products. The last section deals with the evaluation of plastics, including their measurement and manufacturing control. Subjects covered include thermosetting condensation products, cellulosic plastics, vinyl polymers, rubber and the synthetic elastomers, polyesters and polyamides, and the silicones.

Electric Appliance Thermostat

Fenwal Inc., 31 Pleasant St., Ashland, Mass.

The Appliance Thermoswitch Control gives safe, accurate fast-acting heat control to electrical appliances even though exposed to physical shock and vibration. The one-piece welded case and cover assures a tamper-proof unit and stable temperature settings. The temperature adjusting screw will not drift under normal vibration, and torque applied to the terminal binding



posts will not shift contact support members. The thermostat can be side or bottom mounted and was designed to control temperatures in flat surface applications including: flat irons, water heaters, sterilizers and hot plates. There are two models, one for control from 175 to 600 F, the other for the range 50 to 250 degrees Fahrenheit. The maximum load rating is 1,200 w on 110 v, 60 cycle current.

Metal Drying Liquid

Enthone Inc., Dept. MHP, 442 Elm St., New Haven 2, Conn.

Hydrex, a water displacing liquid, is a thin mobile solution that sheds water from the surfaces of metal. It has high penetrating power and will force water out of blind holes and crevices. This process can be used for drying plated work to prevent staining, and to prevent dissolved solids from settling out of hard water on to metal surfaces. Hydrex No. 1 has a flash point slightly above 100 F, and evaporates readily at shop temperatures. The metal parts should be rinsed in cold, running water and then immersed in the liquid. After

Do these false beliefs keep you from converting to aluminum?

(Below are *4 misstatements* commonly applied to aluminum. Have *you* made any of them?)

1. "Aluminum is not readily adaptable to my product"

Fact: Kaiser Aluminum comes in a wide range of alloys to meet every type of manufacturing operation, and can be formed, drawn, spun, brazed or joined. It can be painted or polished, or finished in almost any way you choose. To select the alloy specifically suited to your requirements, simply call on a Permanente Metals' engineer.

2. "Aluminum costs too much"

Fact: While prices of other materials have steadily risen, aluminum is now *at the lowest price in history.* Figured *not* on a per pound basis, but on *unit cost,* aluminum prices (which include freight charges) compare favorably with those of any other metal or material. In addition, savings made on handling, finishing and shipping cut costs substantially.

3. "My competitors aren't converting. Why should I?"

Fact: Scores of manufacturers are speeding their products to market — by converting to aluminum. That's true of makers of general appliances, residential buildings, air conditioning units, heating and ventilating ducts, garage doors and window frames, office appliances and cabinets . . . *plus dozens more.* Their experience can help *you.*

4. "I can't be sure of a steady, long-term supply"

Fact: This is *especially* wrong *today.* For Permanente Metals now offers you a new source of aluminum . . . Kaiser Aluminum. In but a single year of operation Permanente Metals' mammoth aluminum plants produced 175 million pounds of plate, sheet, and strip aluminum. Almost as much as the entire industry produced in the most productive year before the war.

To the above facts add these . . .

Aluminum's resistance to corrosion cannot be matched. Nor can its strength per pound — it can give you the strength of steel at one-third the weight.

Aluminum's appearance can put an extra sparkle of *saleability* on many products, giving them a competitive edge.

In the light of all these *facts,* can you afford NOT to investigate the possibility of converting to aluminum? Call any Permanente Metals' office and an experienced sales engineer will be on the job, for *you!*

Ready to serve you—today . . . **Kaiser Aluminum**

a Permanente Metals product

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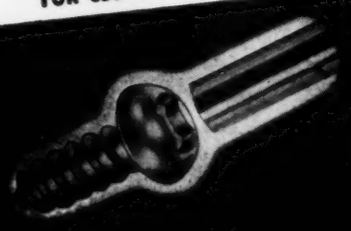
Increase assembly speed up to 50%! Cut down injuries to workers with no burrs, no skids. Reduce production costs. Reduce rejects! Improve product appearance! Go modern with Phillips!

FOR CLUTCH-HEAD SCREWS



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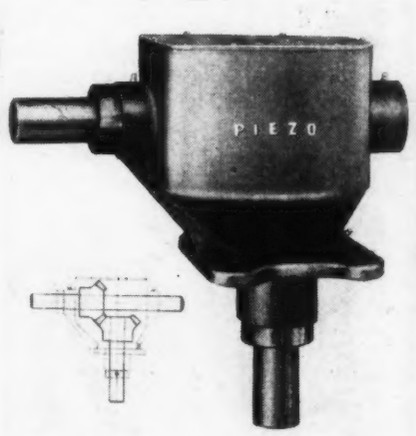
the liquid dries, a thin oil film remains on the surface. This film acts as a rust inhibitor or can be removed by dipping in solvent naptha or by use of vapor degreasers. The liquid is used in a vat with a drain at the bottom. The displaced water collects in the bottom of the vat and can be drained off. Hydrex No. 2 is similar, but has a flash point above 150 degrees Fahrenheit.

Mitre Gear Box

Prezo Mfg. Corp., Dept. EP; 110 E. 42nd St., New York 17, N. Y.

For use with medium speed power drives or hand operation, the Type MG Mitre Gear Box supports and incloses a pair of steel, right angle, 1:1 ratio gears. The cut gears meet torque and power ratings in conformance with the standards of the AGMA. The box is



available, with bronze or roller bearings, in six sizes—½ to 1¾ in. shaft diameters. The solid mounting base can be fastened to a flat surface with four bolts or to structurals with a bracket. The horizontal shaft is rigidly supported by two bearings so a handwheel, pulley or sprocket can be operated on the shaft without additional support.

Bronze Safety Valve

Manning, Maxwell & Moore Inc., Bridgeport 2, Conn.

The Consolidated Safety Valve Type 1664 is for use with air compressors and air and gas holding receptacles. A Nylon disk is used, seating against bronze. Nylon was found to have the necessary characteristics of wear resistance, hardness and flexibility for air line work. Nylon will not flow or creep under spring compression and it will not stick to the seat. It is just flexible enough to fit the seat exactly and has a recovery characteristic that quickly seals off the slightest air leakage after the valve pops. The safety valve is 2¾ in. high and meets all ASME requirements for unfired pressure ves-

Reduces Cost of Machine Base 40% by Change to Welded Steel

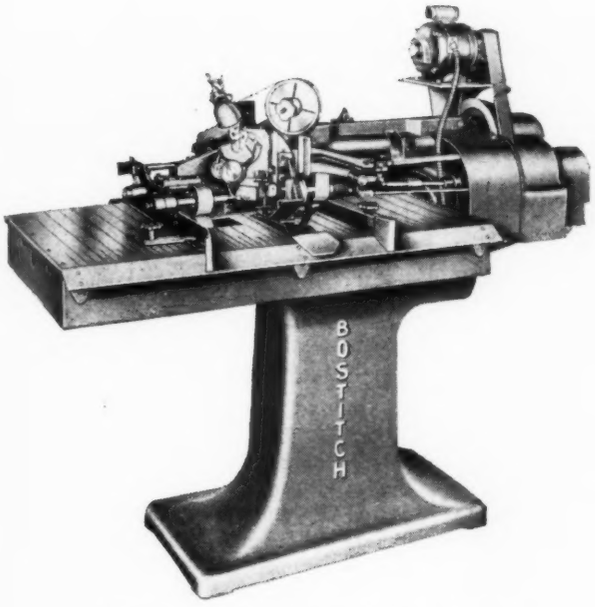


Fig. 1. The Bostitch Stitcher with conventional base.

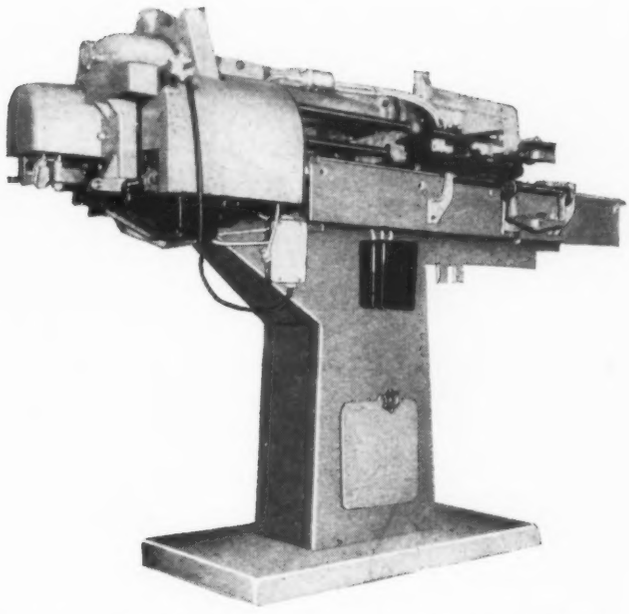


Fig. 2. Rear view of same machine, mounted on new welded base which cost 40% less.

By R. H. Dell, Chief Engineer
Boston Wire Stitcher Company, Westerly, R. I.

CONFRONTED with ever-rising casting costs for the base of the Bostitch Automatic Box Stitcher, we decided to try welded steel design. The result is a base that costs 40% less and is 30% lighter in weight.

Fig. 1 shows the Stitcher with its original base of conventional design, and Fig. 2 shows the same machine, photographed from the opposite side, mounted on the new welded base.

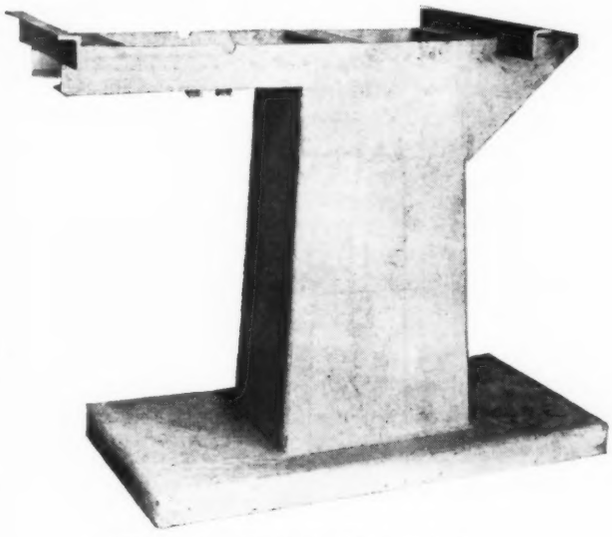


Fig. 3. The welded base without mechanism.

We had been getting the base from an outside foundry and wished to continue having it fabricated outside, so asked commercial welderies for prices on the welded base. This put the former design and the welded design on the same competitive basis.

The lowest bid on the welded base was 40% less than the price we had been paying for the former design. There was also a weight reduction of 30%, the welded base weighing only 525 pounds as compared with the former design's weight of 750 pounds.

Fig. 3 is a close-up of the welded base. The main designing consideration was the great amount of pounding it takes, due to the action of the mechanism in making up to 400 stitches per minute in heavy cardboard containers.

The pedestal, of liberal dimensions to counteract vibration, is one piece of $\frac{5}{16}$" plate. Corners are notched out, sides bent down and butt-welded at the corners. The column is four pieces of $\frac{5}{16}$" plate, flame-cut to shape and corner welded. To minimize material at the top of the column, bare angle irons $\frac{3}{8}$" thick are used for the table mountings. The gusset support had to be extremely strong to absorb the main impact loads, so its top support plate is 1" thick and sides and bottom are $\frac{1}{2}$" plates.

All welds are single pass, square butt welds, not scarfed. "Fleetweld 7" electrode is used.

After changing to the welded base, we discovered an additional market for the same machine with the base $10\frac{1}{2}$" shorter. To make the adaptation, all we did was cut $10\frac{1}{2}$" off the bottom of the vertical column before the weldment was assembled. This flexibility of welded design gives us a further advantage.

The above is published by LINCOLN ELECTRIC in the interests of progress. Machine Design Studies are available to engineers and designers. Write The Lincoln Electric Company, Dept. 367, Cleveland 1, Ohio.

MACOID will help you PLAN it in PLASTIC

In the plans you will be drawing tomorrow,
there's a place, perhaps, for Plastics.
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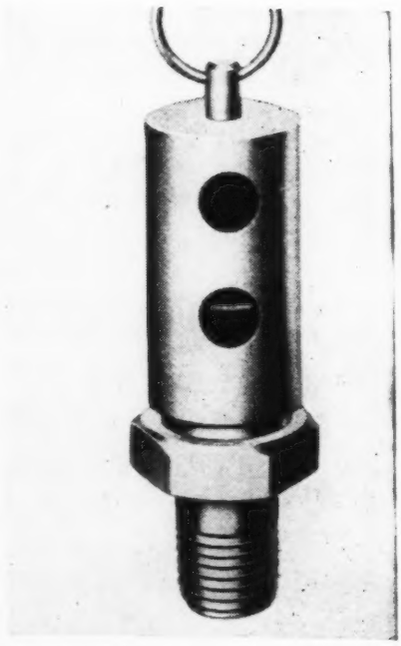
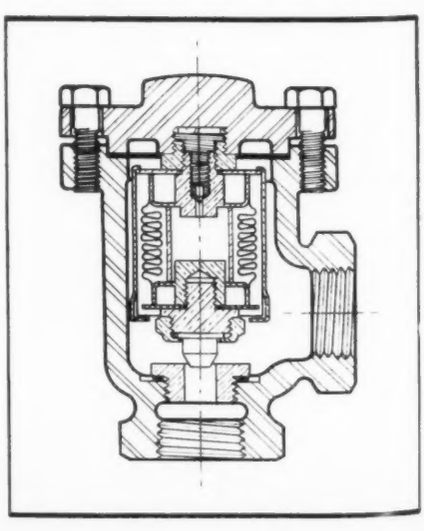


sels. It will operate at any set pressure up to 250 psi and is available with either ⅛, ¼, ⅜ or ½ in. NPT male inlet connection. This valve is also made with a stainless base, cadmium plated cap and spring and is used as a relief valve on automatic beverage vending machines.

Thermostatic Steam Traps

Sarco Co. Inc., 475 Fifth Ave., New York 17, N. Y.

The thermostatic element of the steam trap No. 9 is a helical bellows that permits a larger orifice than can be used on float or bricket traps. The great air venting capacity provides rapid heating from a cold start. This cast steel trap is used in systems where external explosion are liable to occur, where corrosive condensate must be handled and where pressures of 300 psi or total temperatures of 500 F are expected. These limits apply when a stainless steel element is used. Another of this series has a bronze element and can be used where



when precision switches need rubber seals...

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gets the job!

The rubber that seals precision switches is vital to the success of many electrical operations.

An excellent example of a control mechanism that requires a high-quality seal for dependable operation under a wide variety of operating conditions is the Die Cast Enclosed Switch produced by MICRO SWITCH DIVISION OF FIRST INDUSTRIAL CORPORATION. This switch is widely used for safety, limit and other control applications on machine tools and industrial equipment. It features ruggedness, light weight, compactness, high electrical capacity, reliability, ease of mounting and long operation life.

Function of the seal is to keep out moisture, dirt, oil and dust. The effectiveness of the seal in performing this function determines the reliability of operation of the switch. That's why "Micro" engineers, working with the rubber technologists of Acushnet Process Company, selected Perbunan as the logical material for this sealing application.

Both by test and by use Perbunan proves its exceptional ability to resist deterioration from abrasion, heat or cold, oil or water. And a new stabilizer has been added that keeps even delicate color shades constant...with no discoloration of the fluids or materials it contacts.

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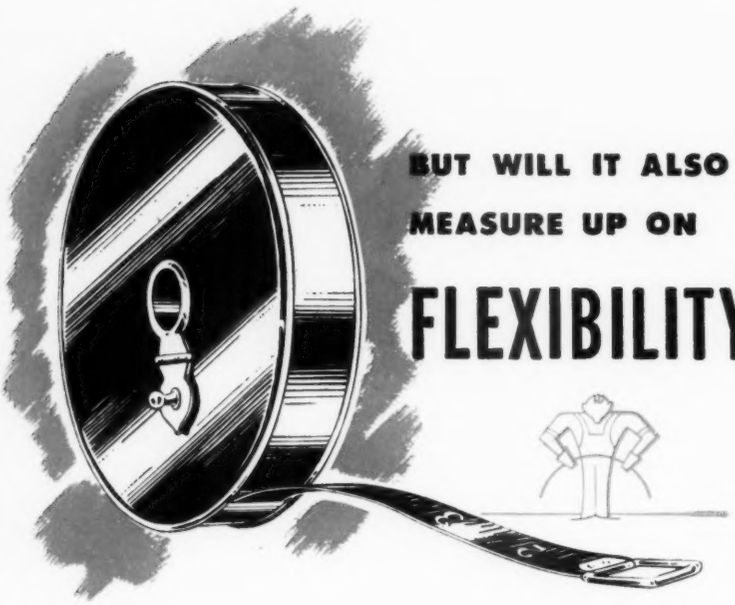
YOU CAN GET AN ORGANIC FINISH WITH

ADHERENCE...



BUT WILL IT ALSO MEASURE UP ON

FLEXIBILITY?

Unichrome* Coatings offer you the Right Combination of properties for your product...every time!

ADHERENCE ALONE isn't enough in a finish when the product may be subjected to twisting or bending—as in a measuring tape, for example. You need *flexibility* also, to prevent chipping or cracking.

And when you can also get *film hardness,* and clear, high *gloss* in the *same* synthetic coating—you have a finish that's really outstanding! Those are the very properties—all four—offered you in Unichrome Coating B-115.

Which is why one manufacturer chooses B-115 to help "sell" flexible steel tapes. Another manufacturer finishes strip with B-115 *before* fabricating his product, for he finds those properties permit subsequent forming without any harm to fine appearance!

Whatever you make, chances are there's a Unichrome finish with the right combination of properties for it—ready to help you save on rejects and build sales. Write today for more details on Unichrome Synthetics and Lacquers.

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SYNTHETIC COATINGS AND LACQUERS

Products of

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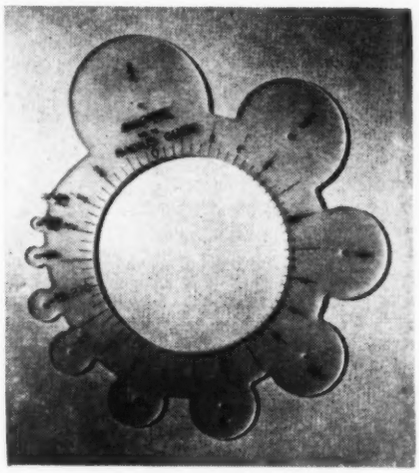
maximum pressure and temperature are not higher than those for 225 psi saturated steam. The cast steel body and cap give the strength necessary to withstand external explosions.

Radius Guide

Rapidesign Inc., P. O. Box 592, Glendale, Cal.

The Radius Guide, No. 75, does away with the time consuming method of finding the correct center with compass and the trial and error process. The

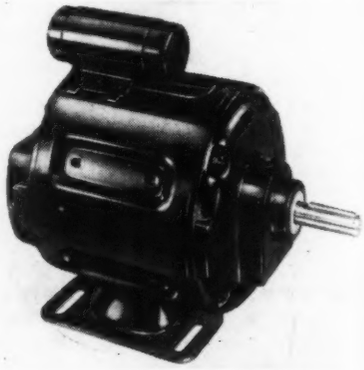


overall diameter of the instrument is 4½ inches. The guide is made of 0.030 in. transparent, drafting quality, sheet plastic. Calibrations of the internal protractor and all numerals are imprinted on one surface.

Drip-Proof Electric Motor

Eicor Inc., 1501 W. Congress St., Chicago 7, Ill.

This 1 hp a-c motor has a starting torque three times as large as the full load torque and has power equal to twice the full load torque available to take care of momentary overloads. Cool operation is obtained by fan ventilation and by heat dissipation through the heat conducting parts. Since the terminal box is accessible, leads can be easily changed to give reversed rotation. This motor takes line voltage variations from 104 to 126 v on lower



Out-of-round

means

out-of-stock

This studied revolution of a Federal Ball Bearing is the forerunner of many thousands at high-speed every minute of its long operating life. The O.D. high and low spots, which mean taper and out-of-round, are intercepted at this point of Federal's inspection control. I.D. grinding, too, is held to such critical account to assure that bores are cylindrical, not bellmouthed, tapered or out-of-round.

Proper operating fit is the end result...correct running clearances maintained between the housing and shaft.

Taking the "measure" of a bearing to Federal's rigid standards involves over 100 individual production, inspection and cleaning operations—with *every fourth operator an inspector*. Out of this system of check and re-check, fifty years in the developing, Federal Bearings are equipped to deliver friction-free performance on any assignment.

Your application may benefit from a Federal Ball Bearing installation. Our representative in your vicinity will gladly talk it over with you. Write for catalog "K." It describes the complete line of Federal Ball Bearings.

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FEDERAL BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

Time Tested

DARNELL
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feature a DOUBLE BALL-BEARING SWIVEL HEAD —assuring the easiest handling of the heaviest loads on any type floor.

DARNELL CORP. LTD. 60 WALKER ST. NEW YORK 13 N.Y.
LONG BEACH 4 CALIFORNIA 36 N. CLINTON CHICAGO 6 ILL.

setting, and from 207 to 253 v on higher setting, with full rated power delivered. The motor will operate on either 115 or 230 v a-c by making simple connection changes.

Toughness Tester

The Hall Planetary Co., Fox and Abbotsford Ave., Philadelphia, Pa.

This toughness tester provides a simple and direct method for testing the quality of high speed steel in cutting edges of tools after heat-treatment. The test piece is placed on the anvil beneath the

stylus punch. Pressure on the punch is slowly increased until the tool edge breaks. The gage reading at rupture and a visual inspection afterward are an index of the toughness of the material at the service edge. A clean break with displacement of a small volume of metal indicates a satisfactory tool steel, properly heat-treated. Spalling indicates a cutting edge with poor wearing qualities.

Ball Bearings

Marlin-Rockwell Corp., Jamestown, N. Y.

A standard-dimension bearing equipped with seals on one or both sides, the "Synthe-Seal" is efficient in the retention of lubricant. The seals are made of soft synthetic rubber with a steel core for strength. The pliable rubber wiping lips are in contact with a ground, curved surface on the inner race. These seals exclude dirt, moisture and other harmful substances. The synthetic rubber is not affected by water, oil, grease or solvents. The operating temperatures for these bearings range from −30 F to +225 F, and the seals

STANDARDS and SPECIALS by the *Millions*

Simply Specify—

"SHINYHEADS" NC or NF Thread | **"HI-CARBS"** NC or NF Thread | **"SHINYLANDS"** Standard Thread

"SHINYHEADS"
America's Best Looking Cap Screw

Made of high carbon steel—AISI C-1038—to standards for full finished hexagon head cap screws. Heads completely machined top and bottom. Hexagon faces clean cut, smooth and true, mirror finish. Carried in stock.

"HI-CARBS"
Heat Treated Black Satin Finish

Made of high carbon steel—AISI C-1038. Furnished with black satin finish due to heat treatment. Hexagon heads die-made, not machined. Point machine turned; flat and chamfered. Tensile strength 130,000-160,000 p.s.i. Carried in stock.

FILLISTER CAP SCREWS
Heads completely machined top and bottom. Milled slots—less burrs. Flat and chamfered machine point. Carried in stock.

FLAT HEAD CAP SCREWS
Heads completely machined top and bottom. Milled slots—less burrs. Flat and chamfered machine point. Carried in stock.

SET SCREWS
Square head and headless—cup and oval point—case hardened. Carried in stock.

"SHINYLAND" STUDS
All studs made steam-tight on tap end unless otherwise specified, with flat and chamfered point. Nut end, oval point. Carried in stock.

"SHINYTHREADS"

AIRCRAFT ENGINE STUDS
Made of highest aircraft quality alloy steel, finished to extremely close thread and body tolerance, with precision rolled threads—both straight and step types.

CONNECTING ROD BOLTS
Made of alloy steel—heat treated—threads rolled or cut—finished to extremely close thread and body tolerances—body ground where specified.

SPRING BOLTS
Case hardened to proper depth and ground to close tolerances. Thread end annealed. Supplied in various head shapes, with oil holes and grooves of different kinds, and flats accurately milled.

VALVE TAPPET ADJUSTING SCREWS
Hexagon head style—to blueprint specifications—hexagon head hard; polished if specified—threads soft to close tolerance.

STANDARDS carried by **LEADING DISTRIBUTORS**

SPECIALS furnished to **BLUE PRINT SPECIFICATIONS**

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2179 SCRANTON ROAD • • • CLEVELAND 13, OHIO

Pioneers and Recognized Specialists, Cold Upset Screw Products since 1907

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ADEL *Hydraulic Equipment*

PRECISION-BUILT PRODUCTS FOR PRECISE CONTROL

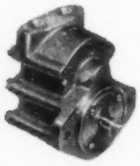
The operating characteristics of hydraulics are unsurpassed for control of industrial machinery. When adapted for additional work capacity of existing machinery, or as a labor-saving device, hydraulics provide a wide range of power, precisely controlled as to timing, speed and force.

Adel Precision Products Corp. is well versed in hydraulic applications. Adel precision-built hydraulic equipment is engineered to the requirements of each particular installation. Here are a few of the products in the Adel Industrial line of hydraulic equipment:

POWER TO HOLD OR CLAMP

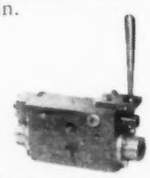
HYDRAULIC ACTUATING CYLINDERS—Adel Actuating Cylinders provide linear force, to pull, push, lift or lower. Available in either single or double acting types, they are used to operate pressure-actuated machines, presses, hoists, rapid action jigs, farm lifts, etc.

POWER TO MOVE



HYDRAULIC POWER PUMP—Here's a new, gear-type pump designed and constructed especially for hydraulic service. At 2250 rpm, this powerful, compact unit delivers 12.5 gpm at 800 psi. Adel hydraulic pumps may be direct connected to motor shaft, or driven by belts, gears or chain.

POWER TO CHANGE POSITION



4-WAY SELECTOR VALVE—Upon release of handle, valve automatically returns to neutral position. In this position, pressure is connected to return and an integral lock valve positively holds the actuating cylinder in position. This valve is particularly adaptable to such applications as tractors, cranes, hydraulic presses, etc.

POWER TO CONTROL

SOLENOID VALVES—Adel Solenoid Valves are of the poppet type. They assure long life and fast action, with the least expenditure of electrical energy. They provide instantaneous, effortless control of hydraulic circuits at the touch of a button. Adel Solenoid Valves are used for remote control of hydraulic power or other automatic flow control operations.

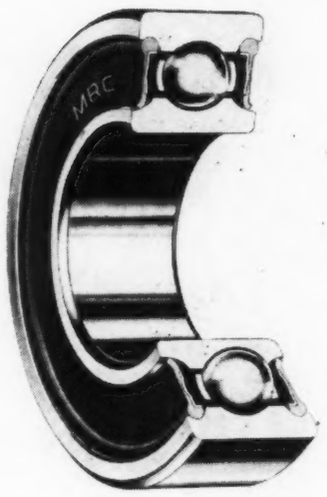
Adel stands ready to work with you on any problem in the field of hydraulics. At your service are Adel's years of experience, extensive manufacturing facilities and practical engineering skill. Address Adel Precision Products Corp., 10757 Van Owen Street, Burbank, California.

ADEL

ADEL PRECISION PRODUCTS CORP.

BURBANK, CALIF. ★ HUNTINGTON, W. VA.

Manufacturers of: Aircraft Hydraulic Systems • Marine & Industrial ISOdraulic Controls • Halfco Self-Aligning Bearings • Line Support Clips & Blocks Industrial Hydraulic Equipment • Aircraft Valves • Industrial Valves

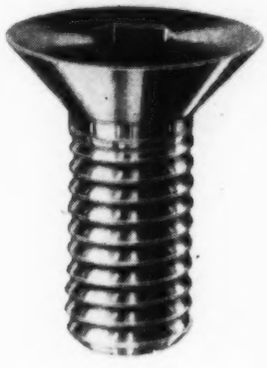


can cause no distortion of the inner or outer races. Synthe-Seal bearings are manufactured in standard SAE single-row bores, OD's and widths and replace other bearings in the same position.

Flat Head Cap Screws

The Holo-Krome Screw Corp., 31 Brooks St., Hartford, Conn.

A new member of the Holo-Krome series, the flat head socket cap screw is made from a special analysis alloy steel. This screw is cold forged, with the ex-

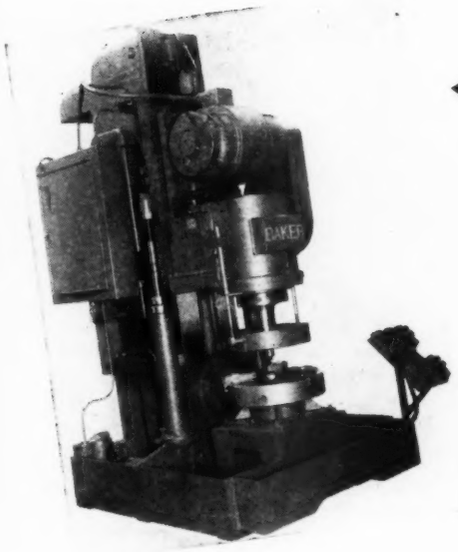


ception of the threads, by a patented process. The hexagonal socket admits standard socket wrenches, and can be turned by an ordinary screw driver if necessary. These cap screws are available in all standard sizes and threads.

Chemically Inert Gaskets

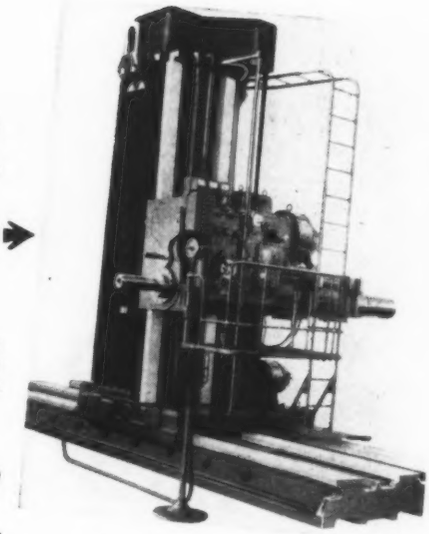
United States Gasket Co., 703 N. 10th Street, Camden, N. J.

Special techniques that impart resilient characteristics to thermoplastic materials are used in the manufacture of Chemiseal gaskets. They are fabricated from Teflon, which is resistant to the chemical action of organic and inorganic acids, bases, esters, ketones,



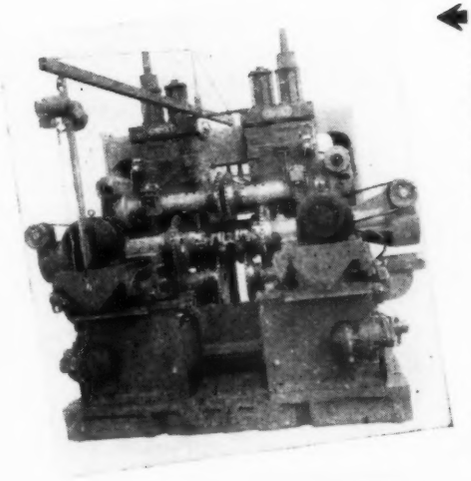
BAKER BROTHERS 40 HP BORING & DRILLING MACHINE.

Cone-Drive to the spindle "gives powerful but smooth transfer of power" to the CARBIDE tipped multiple blade cutter head.



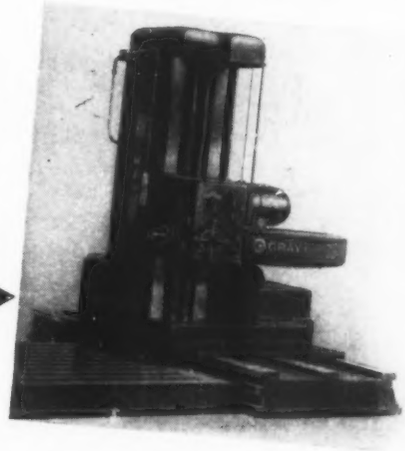
GIDDINGS & LEWIS MACHINE TOOL CO.'S BORING, DRILLING & MILLING MACHINE.

Cone-Drives are used on this as well as other G & L machines for smooth, accurate transfer of power in less space than otherwise possible.



GISHOLT MACHINE COMPANY'S 50-TON 180-HP TURN MILL.

Roughs all rod bearings on a crankshaft from the forging every 2 minutes. The six 24" OD—78 rpm cutters are individually driven from 25 hp motors through 25:1, 10" C.D. Cone-Drives at 445 SFPM. This drive not only transmits high power smoothly but saves considerable space. Two 4" and two 5" C.D. (No. 7415) Cone-Drives rotate the work spindle smoothly at 1 rpm. The 5" Cone-Drives are driven by 2 pinions, one on each side of the gear, arranged so as to eliminate backlash.

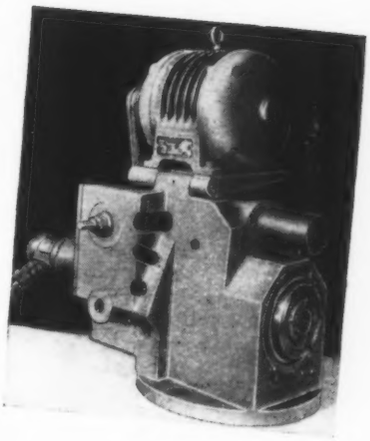


G. A. GRAY CO.'S 36 TON HORIZONTAL BORING, DRILLING & MILLING MACHINE.

7½" C.D. Cone-Drives feed the column smoothly along the runway at ½" to 120" per minute to a micro-jogging accuracy of 0.00025". Gears are self-locking for climb milling conditions, make for compactness by saving space.

MICHIGAN TOOL'S NEW "3-WAY" UNDERPASS GEAR FINISHER.

Faster gear finishing by *any* of 3 methods (selected at will) plus of course real smoothness and accuracy through Cone-Drives to the high speed cutters.



SHEFFIELD CORPORATION'S GEAR CHAMFERING MACHINES.

With Cone-Drive geared heads "for greater accuracy, less chance of backlash, more tooth-to-tooth contact and higher gear strength."

Did you See them at the Machine Tool Show

plus numerous other new Cone-Drive operated machines.

CONE-DRIVE

CONE-DRIVE DIVISION

MICHIGAN TOOL COMPANY
7171 E. McNichols Road, Detroit 12, U. S. A.

YOUR ASSURANCE IT'S DESIGNED RIGHT,
BUILT RIGHT...

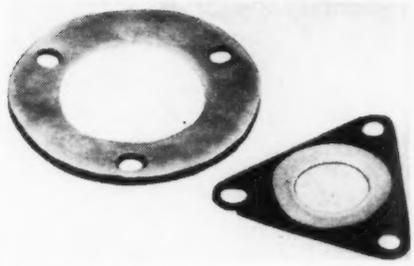
the RIGHT POWER

TO MEET THE MOST EXACTING REQUIREMENTS

To users, dealers, and builders of gasoline powered equipment the world over, the trade-mark on a Briggs & Stratton engine is more than a label. It is a *seal of quality*—backed by the performance record of over 3 MILLION Briggs & Stratton engines during more than 28 years of *continuous production*. No other manufacturer has built so many 4-cycle air-cooled engines, or has had such long experience in building them. That's why the name BRIGGS & STRATTON stands for all that is best in meeting your most exacting power requirements.

Powered Power
FOR INDUSTRIAL CONSTRUCTION RAILROAD AND FARM EQUIPMENT

BRIGGS & STRATTON CORPORATION
Milwaukee 1, Wisconsin, U. S. A.

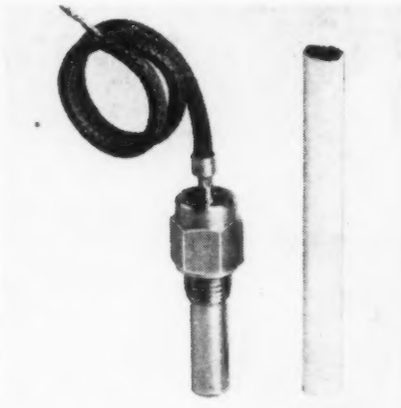


aromatic hydro carbons and halogenated solvents and acids. Melted sodium, and fluorine under pressure cannot be used with these gaskets. Temperatures from −200 F to +500 F will not cause brittleness or decomposition. These gaskets will not stick to flanges or become coated with process materials.

Thermal Limit Switch

Control Products Inc., 306 Sussex St., Harrison, N. J.

Originally designed to provide a thermal switch to warn when excessive temperatures were reached in automotive gear boxes, railway journal boxes, and as an indicator for high or low temperatures in fluids under pressure, the Plug-Stat thermal control and limit switch will operate under conditions of severe virbration, dirt and abuse. It can be installed in a drilled and tapped ⅛-27 N.P.T. or a N.F.-2, ⅜-24 hole. Control ranges from −60 F to +600 F with an amplitude of operation of ± 3 degrees Fahrenheit. The switch, normally open or normally closed, operates from a 28 v, 2 amp. source. The case is fabricated from cold rolled steel, brass or stainless steel, and is hermetically sealed against pressure, moisture—and dirt.



Electroplated Wire

Kenmore Metals Corp., Warren, Pa.

A new type of electroplated wire that can be bent, swaged, hammered, woven, or twisted without flaking can be used in radio tubes, incandescent and fluorescent lamps, electrical appliances and wire goods. Fernicklon is made by con-

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Wherever extraordinary or difficult operating conditions prevail, Sirvene pliable parts deliver dependable service at the very heart of the mechanism. They may control fuel intake, maintain delicate air pressure and fluid ratios, or provide an effective seal against mud, dirt, oil, water and other solubles. In each application Chicago Rawhide engineers custom-develop the Sirvene part from special formulae so that it meets exact specifications in design, elasticity or hardness, resilience, compression set, temperature resistance and tensile strength. Whenever your designs require unusual molded parts, investigate Sirvene first.

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Sirvene products include diaphragms, boots, gaskets, oil seals, washers, packings, and other special molded mechanical pliables.

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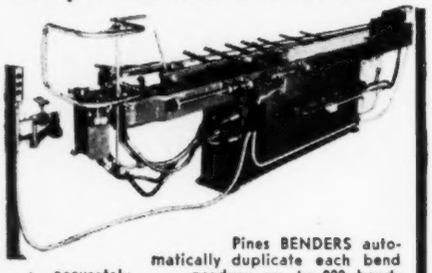
How To Obtain Higher Production and Lower Costs . . . on Pipe and Tube Fabrication

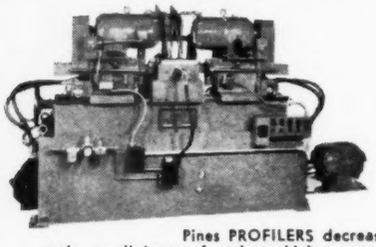
1 2 3 4

Pines Extremely Versatile Units Cut Machining and Handling Time

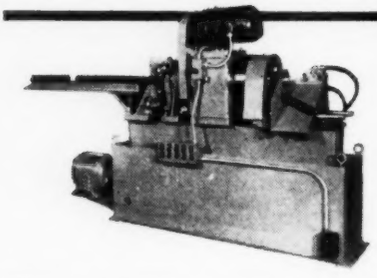
An analysis of your tube and pipe fabrication jobs will indicate that these *four* outstanding Pines machines accomplish worthwhile savings in time and money . . . and offer the ideal method on a wide variety of pipe and tube work.



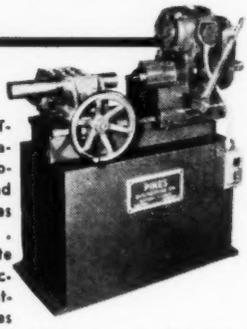
1 Pines BENDERS automatically duplicate each bend accurately . . . produce up to 800 bends per hour . . . Degree-of-Bend Selector reproduces each bend to desired angle maintaining uniformity throughout entire lot . . . quickly set up for any job . . . tooled to prevent wall deformation . . . capacities up to 6" extra heavy pipe.



2 Pines PROFILERS decrease costs on all types of end machining operations through higher output . . . for end-turning, boring, chamfering, threading, tapping, burring, etc. . . . single or double spindle operation . . . fully automatic models equipped with feed and discharge conveyors eliminating in-process handling of work.



3 Pines CUT-OFF machines cut pipe and tubing within a few thousandths inch of specified length . . . fast, fully automatic hydraulic controls . . .quickly interchangeable tools, either parting tool bits or rotary cut-off discs . . . capacity from ½" to 2⅞" O.D. . . . entire automatic machining cycle only 1½ seconds . . . produces up to 1500 pieces per hour . . . one operator can attend several machines.



4 Pines CENTERING machine establishes end center holes in bars . . . simple to operate and highly productive . . . self centering chuck handles up to 5" diameter stock . . . no adjustment required . . . centers either round or square stock.

Pines engineers will recommend the proper size and type of Pines machines from their extensive line for your specific pipe and tube fabricating jobs — without cost or obligation. Today . . . write for this consultation service.

Further Information FREE . . . You can obtain more comprehensive data on how you can use Pines tube and pipe fabricating machines to advantage by sending for your copy of Bulletin No. 107.

PINES ENGINEERING CO., INC. BENDING PROFILING CUT-OFF CENTERING MACHINES AURORA, ILLINOIS

BENDING PROFILING CUT-OFF CENTERING

PINES ENGINEERING CO., Inc.

Specialists in Tube Fabricating Equipment

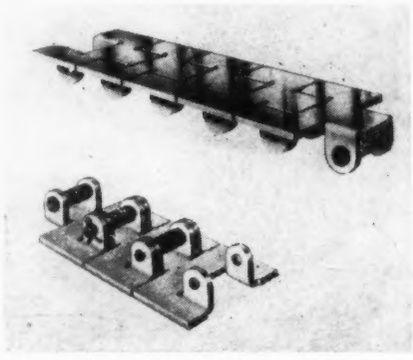
662 WALNUT AURORA, ILLINOIS

tinuously electroplating ¼ in. diameter metal rods and then cold-drawing to diameters as fine as 0.0038 inches. One inch of ¼ in. plated rod can produce as much as 100,000 feet of wire. It can be ordered in continuous sections of almost any length. This wire can be subjected to severe climatic conditions when an anti-corrosive coating metal is used. It can be welded to form a product without destroying the coating at the point of the weld. Types now manufactured include: steel wire with nickel, copper wire with nickel or silver and are available with die polish or satin finishes.

Flat Top Conveyor Chain

The Wade-Morrison Co., 18401 Shaker Blvd., Cleveland, Ohio

This conveyor chain is used for handling bottles, jars, cans, etc., through cleaning, filling, capping and inspection operations, and for moving materials between machines. All links of this chain are identical. The chain is available in 1½ in. pitch and in any width top plate from



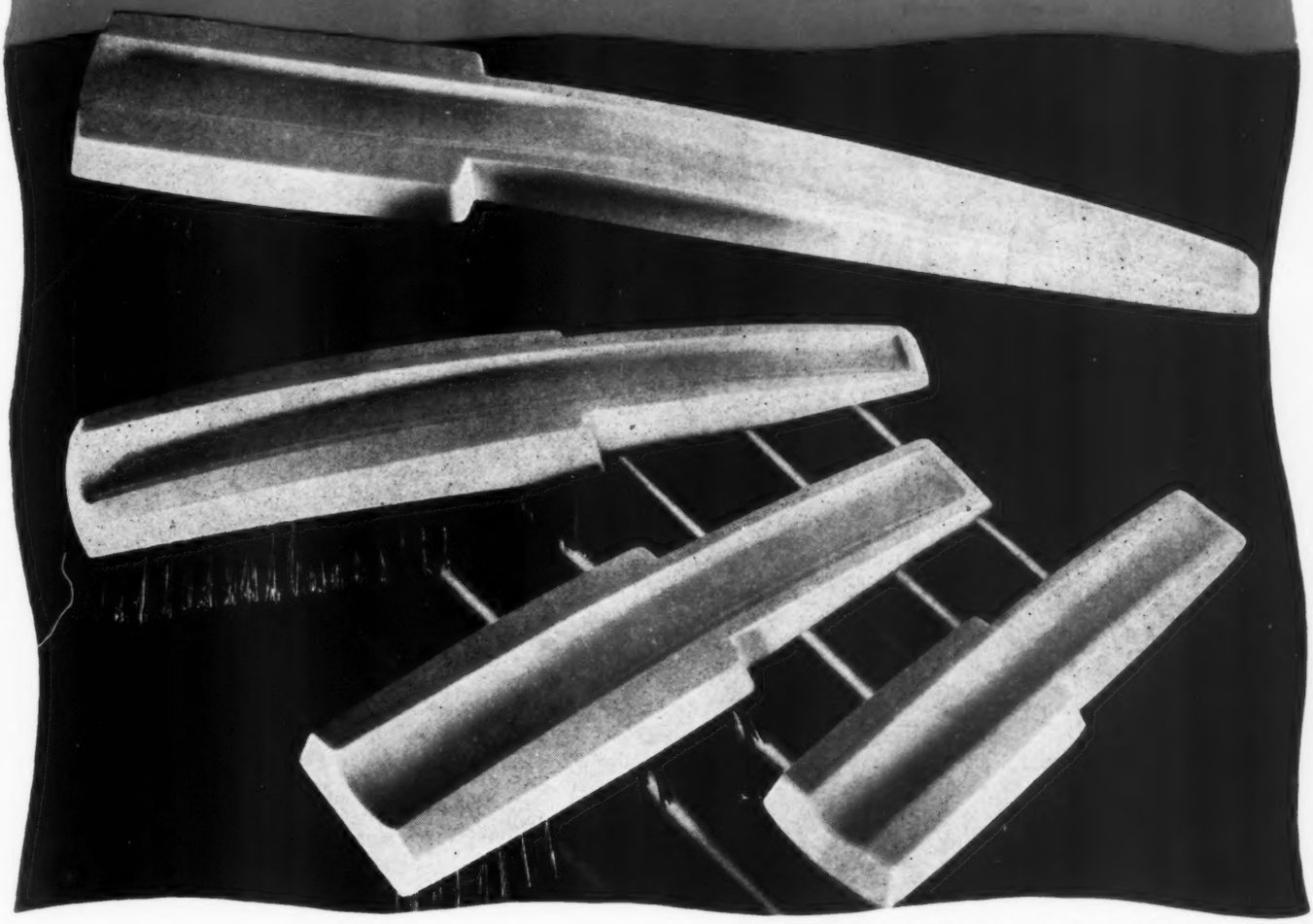
3 to 7½ inches. It can be had in carbon steel with pins and bushings carburized and hardened or in Type 304-18-8 stainless steel with special alloy pins and bushings, hardened to give durability. The top surface of all chain is ground after assembly. This chain will operate over No. 60 extended pitch sprockets or over extra width sprockets to give long wear.

Industrial Relief Valve

Electrol Inc., 85 Grand St., Kingston, N. Y.

Designed for industrial uses with mineral oil, this relief valve can be adapted for use with water in special cases. The valve has a dampening device consisting of a close fitted piston working in oil. The range between cracking pressure and full flow can be kept very small, with cracking pressure reaching 90 percent full flow pressure. The spread between full flow and re-seating pressure can be kept small, with re-seating pressure as high as 85 percent of full flow pressure. The valve is

Fuller Brush restyles with Acetate



Brushes molded by Fuller Brush Company from cellulose acetate supplied by Chemaco Corporation. Brushes designed by J. Gordon Lippincott.

IN RESTYLING its line of personal brushes, Fuller Brush Company chose cellulose acetate plastics above all other materials. Many requirements had to be met by the plastics selected for this important application.

First, the materials had to be extremely tough and resistant to shattering—to withstand the high-speed drilling of holes and the impact of stapling the bristles during manufacture.

These properties, plus good dimensional stability, were essential service requirements, too—in order to obviate loosening of the bristles or cracking of the handles under varying climatic conditions. Other plastics tested did not possess these desirable properties.

Secondly, the plastics had to be moldable to close dimensions and adaptable to the high speed injection process—so as to faithfully reproduce the new designs with the least finishing, and to meet mass-production demands rapidly.

Finally, from a consumer standpoint, the materials selected had to be light in weight; pleasant to the touch; resistant to soap, hot water, and toilet preparations; and obtainable in hues that would have universal eye-appeal.

In meeting all these needs for Fuller Brush Company, cellulose acetate again demonstrates how high quality styling and unusual durability can be combined with maximum economy.

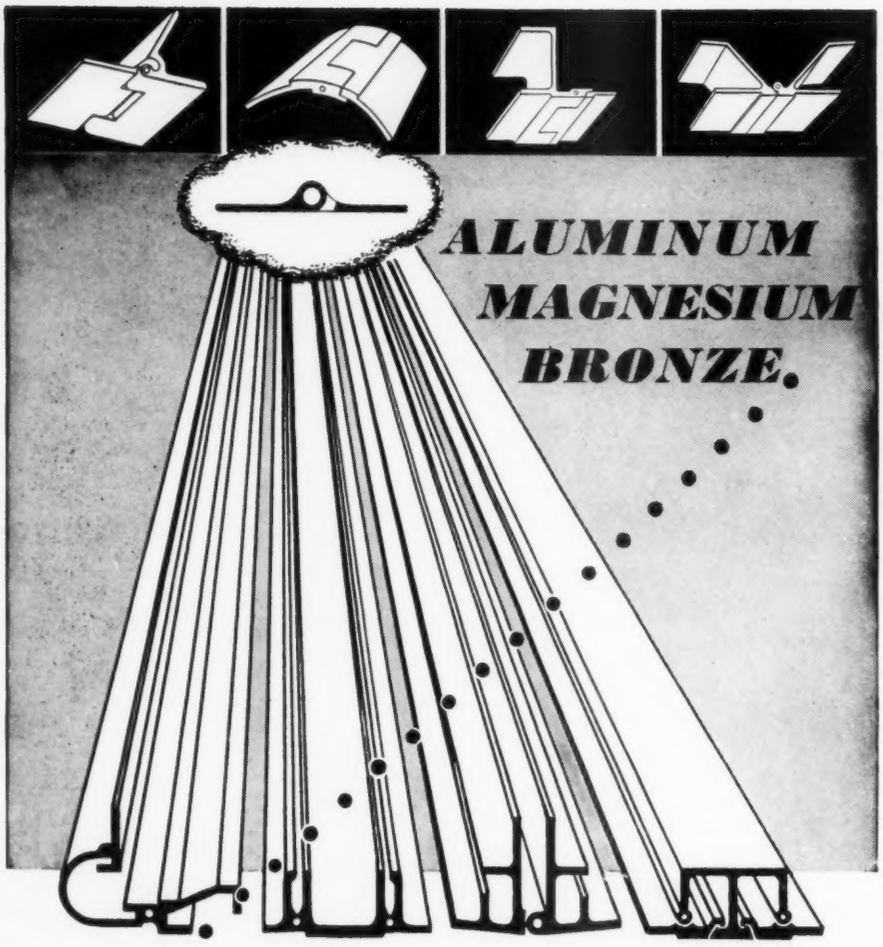
If *you* have a restyling problem, investigate the cellulosics. While Hercules does not make cellulosic plastics or molding powder, we will be glad to send you helpful technical literature on the Hercules base materials from which they are made.

HERCULES POWDER COMPANY
INCORPORATED
904 Market Street, Wilmington 99, Delaware

CP7-10

Save and Sell with Cellulosic Plastics

CELLULOSE ACETATE • ETHYL CELLULOSE • NITROCELLULOSE



MOYNAHAN

FABRICATIONS

. . . Hinges for a Thousand Uses

There *is* an answer to your hinge or connector problem—Moynahan Fabrications. Moynahan engineers have developed hundreds of extruded hinges and connectors to meet customers' specific needs. They're available to you, too, in lengths from 0′1″ to 21′0″—in aluminum alloys, magnesium, bronze—in non-corrosive finishes, bright, or in colors to match any product.

Moynahan hinges and assembly connectors are *engineered* to your individual requirements for strength and appearance. Tested structural members—precision machined—with perfectly matched loops and spaces for universal interchangeability. Hinges, yes—but with a beauty dividend.

Many of the following products are designed to include Moynahan custom hinges and fabrications. They may suggest a solution to your hinge or assembly problem.

Aircraft
Displays
Music Boxes
Furniture
Trailers
Shipping Cases
Radios
Shower Doors
Railroad Cars
Luggage
Refrigerators
Light Fixtures

Our new catalog will prove of interest to your engineering department. Why not send for your copy today?

MOYNAHAN BRONZE CO., 9073 ALPINE AVENUE, DETROIT 4, MICH.

Designers & Manufacturers of INDUSTRIAL METAL PRODUCTS

available in two models with bodies of 17 ST heat-treated aluminum alloy. with poppet valve and seat hardened and ground steel. Both models have a 500 to 2,100 psi pressure range. Model 523-8, 5 x 2 x 1⅜ in., has ⅜ — 18 N.P.T. ports with 6 gpm maximum flow. Model 523-14, 8½ x 2⅜ x 3¼ in., has ¾ — 14 N.P.T. ports with 16 gpm maximum flow.

Indicator Lights

American Electronics Corp., 226 N. Fourth St., Columbus, Ohio

Neon-glow lamp indicators are for use as a sub-assembly where lighted indicators are desired. They are available in diversified types to meet a wide range

of requirements in method of mounting, visibility, appearance and light brilliance. These bulbs have a minimum current consumption and a long life compared to incandescent lamps. Units are provided with or without shielded lead wires. The heat resisting housing incloses a neon glow bulb, permanent or replaceable, and proper resistance for operating on a-c or d-c voltage of 70 volts and upward.

Miniature Fluorescent Lamps

Stocker and Yale, 48 Birch St., Marblehead, Mass.

Microscope and general utility lamps that can be used to promote safety as well as visibility give an intense light at 3 in. working distance. The twin 4 w lamps straddle the objective lens, when used on a microscope, and prevent

Which Coupling Shall I Use?

Here are four types of BOSTON couplings suitable for a wide range of applications from "flea" power up to 100 horsepower—available in 69 different stock sizes!

1 This is what is known as the Renold-Hardy flexible coupling and is made up of a flexible disc. of vulcanized rubbered fabric inserted between two metal flanges with hubs. It is available in various sizes capable of transmitting from 1 horsepower up to 100 horsepower.

2 This coupling is known as BOSTON type "FCN"—a three-jaw coupling and is made of a high grade, low carbon content steel with a non-metallic cushion between the jaws to absorb vibration or shocks. It is available in bore sizes ranging from 3/8" to 1½" diameter.

3 This coupling is known as BOSTON type "FA"—a multi-jaw coupling and is made of untreated steel. This coupling is particularly well suited for use with small displays or other light duty applications. It is available in bore sizes ranging from 3/16" to ½" diameter.

4 This coupling is known as BOSTON type "FCB"—a special ball bearing type flexible coupling and is made of case-hardened steel with an insert having hardened and ground steel balls. The greater flexibility of this coupling over an ordinary jaw coupling removes the strain between motor and machine, permitting unrestricted end play of motor shaft. It is available in bore sizes ranging from 3/8" to 1½" diameter.

One of the main features of these couplings is that practically all 69 sizes are carried in stock ready for immediate delivery. Send for your copy of Boston Gear Catalog 54 listing these 69 couplings as well as all other Boston Power Transmission Equipment and Component Machine Parts.

BOSTON GEAR WORKS • INC.

NORTH QUINCY 71, MASSACHUSETTS

GENTLEMEN: Please send me_____copies of Boston Gear General Catalog 54 containing complete specifications and list prices of your couplings and all other Boston Power Transmission Equipment and Component Machine Parts.

NAME_____

COMPANY_____

STREET_____

CITY_____ ZONE_____ STATE_____

Silicone News

DC SILICONES

PHOTO COURTESY COLLMAN MANUFACTURING CORP.

DC 44 Silicone Grease is used to lubricate this new electric shaver made by the Collman Manufacturing Corp.

FOR A LONG LIFE OF TROUBLE-FREE SERVICE

In electric shavers or locomotives, the basic requirements are the same—long life and trouble-free service. These requirements are met by designing and redesigning to capitalize on the properties of the best materials available.

The kind of lubricant used is frequently as important as the materials of construction or the tolerances and workmanship. An unusual example is the experience of Collman Manufacturing Corporation of Erie, Pa., makers of the Collman "58" electric shaver.

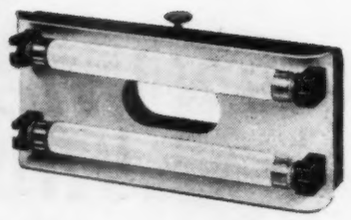
In this shaver a small four pole motor on a case hardened steel shaft rotates at high speed in plastic laminated bearings. Many organic greases were tried, but none of them had enough lubricity to increase the original speed of the motor. But use of DC 44 added 1500 r.p.m.—proof of its excellent lubricity between hardened steel and plastic bearings.

And DC 44 stays where it's put. Bleeding of DC 44 is less than 2% after 16 hours at 110°C. That means more permanent lubrication. It also means more trouble-free operation in this application where the electrical contact points are only half an inch from the bearings. Organic greases migrated, decomposed on the contact points, and stopped the motor. DC 44 has less tendency to migrate and it does not decompose to form troublesome gums or sludges.

In the trend toward really permanent lubrication the DC Silicone Greases are inescapable. You'll find them described in data sheet No. C7-5.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN
New York • Chicago • Cleveland • Los Angeles
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

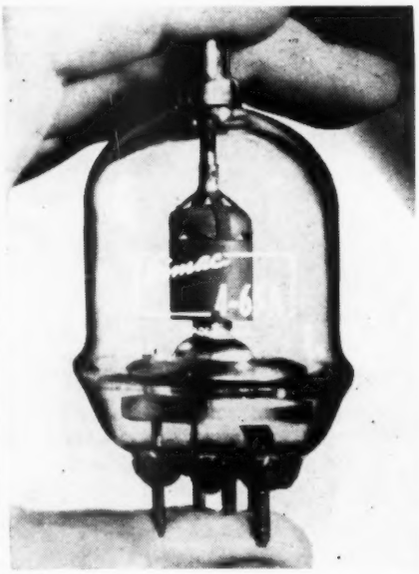


halos, highlights and shadows. The unit can also be used to illuminate belts, moving parts and benches in manufacturing plants. The twin lamp measures 1⅜ in. high, 2¾ in. wide and 6¼ in. long. It operates on 115 v 60 cycle a-c, and the ballast is built into the plug connector.

Low Voltage Tetrode

Eitel-McCullough Inc., 178 San Mateo Ave., San Bruno, Cal.

Physically small, radiation cooled, and designed to fit available sockets, Type 4-65A tubes were made to fill the need for a low voltage tetrode suited for



mobile applications. It features an instant heating 6 v thoriated tungsten filament, non-emitting grids and a processed metal plate; all inclosed in a hard glass envelope. Good performance is obtained over the entire rated plate voltage range; 400 to 3,000 volts.

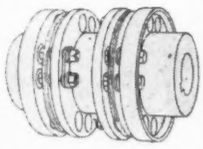
Motor Controllers

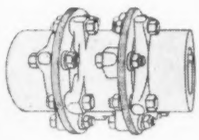
Furnas Electric Co., 444 McKee St., Batavia, Ill.

The Furnas A series of 1 hp electric motor controllers was designed for medium industrial or work shop equipment. They are available in four switching arrangements: reversing, two-speed, series-parallel and three-pole "off-on". The case, handle and contact rotor are made of plastic. The

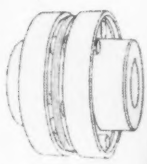
THOMAS Flexible ALL METAL COUPLINGS

Engineered to stand up on the toughest jobs, Thomas Flexible Couplings do not depend on springs, gears, rubber or grids to drive. All power is transmitted by direct pull.



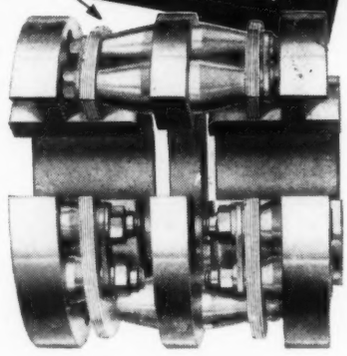


The standard line of Thomas Couplings meets practically all requirements. But if unusual conditions exist we are equipped to engineer and build special couplings.



BACKLASH FRICTION WEAR and CROSS-PULL are eliminated NO LUBRICATION REQUIRED!

PATENTED FLEXIBLE DISCS



THE THOMAS PRINCIPLE GUARANTEES PERFECT BALANCE UNDER ALL CONDITIONS OF MISALIGNMENT

Write for New Engineering Catalog

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

NOTE THIS COMPLETE TABLE OF CONTENTS

- Materials
- End Connections
- Dimensional Tolerances
- Straps and Supports
- Galvanizing and Painting
- Testing
- Stress Relieving and Heat Treating
- Instructions for Ordering Pipe Coils
- Recommended and Minimum Dimensions
- Designations of Pipe Coils
- Listing of Common Types of Pipe Coils
- Headers
- Pipe Data
- Length of Pipe in Bends
- Engineering Data
- Accessories for Pipe Coils

48 Pages of Useful Pipe Coil Information

All the information you usually need when designing or specifying pipe coils is in this new Crane Circular No. 318. Here's where you'll find all the dimensions you need. Also diagrams of all common type coils, and photos of many others.

The engineering data section contains a lot of handy tables and charts, also working data on the theory of heat transfer through pipe walls, and on heating water with steam. Every page gives practical help.

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You'll like Circular 318 for complete and accurate reference on pipe coil specifications, and for getting good, sound pipe coil values. Its entire content is based on laboratory and field research, and on Crane Co.'s long experience as the leading designer and fabricator of piping equipment for all applications.

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AMERICAN HOT-DIP GALVANIZERS ASSOCIATION INC.

"If it carries this Seal it's a job well done"

This insignia on your galvanizing job designates that it has been done by a member of the American Hot Dip Galvanizers Association whose membership is pledged to the highest standards of practice and ethics in the galvanizing industry.

It means that each member of the Association has access to the collective "know how" and the experience of the entire membership.

It is your assurance of the highest quality in materials and workmanship, the latest in equipment and most modern of methods.

Any of the Association's members will gladly give you estimates on your galvanizing requirements.

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WILCOX, CRITTENDEN & CO., INC., MIDDLETOWN

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OLIVER IRON & STEEL CORP., PITTSBURGH
PENN GALVANIZING COMPANY, PHILADELPHIA

TENNESSEE
M. M. HEDGES MFG. COMPANY, INC., CHATTANOOGA

TEXAS
NOWERY J. SMITH COMPANY, HOUSTON

WASHINGTON
ISAACSON IRON WORKS, SEATTLE

WISCONSIN
ACME GALVANIZING, INC., MILWAUKEE

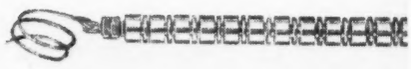
AMERICAN HOT DIP GALVANIZERS ASSOCIATION, INC.
FIRST NATIONAL BANK BLDG.
PITTSBURGH 22, PA.

unit can be mounted in various ways with available brackets and plates. These controllers are rated 1 hp, single and 3 phase, 110 to 550 v a-c; ¼ hp 115 to 230 v d-c; and non-inductive loads; 10 amp 110 v a-c or 5 amp 220 v alternating current.

Controlled Electrolyzer

McRay Sales Co., 1156 E. Colorado St., Pasadena 1, Cal.

A number of zinc and copper plates, mounted in series, make up the McRay Electrolytic Treater. This unit controls electrolysis, removes scale and corrosion, and prevents its formation in boilers. The device sets up an electrolytic force that renders the salts and minerals inert. Normally installed in a



preheater just ahead of the boiler, this unit can also be used in water heaters, automotive engines, stationary engines, and oil well pumps. The treater requires a minimum of attention after installation, and keeps the boiler tubes, steam valves, controls and steam distribution piping in good condition. Various sizes are available to fit all boilers.

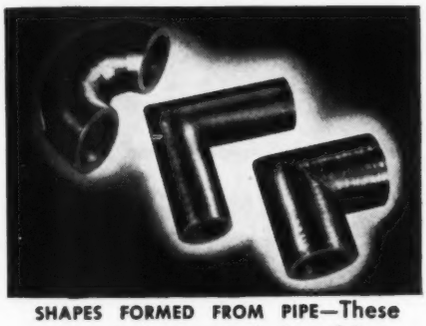
Electronic Circuit Tester

Precision Apparatus Co. Inc., 92-27 Horace Harding Blvd., Elmhurst, L. I., N. Y.

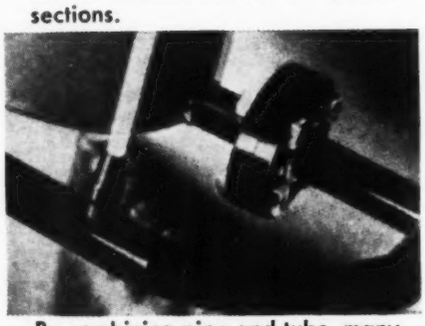
Available in laboratory and portable models, the Precision Multi-Master Series 858 is a sensitive 20,000 ohm per volt, wide range test set used for high-speed measurements in modern electronic circuits. It contains an automatic push button range and function selection system. All standard functions are available at only two polarized tip jacks. One row of five buttons selects all func-

Design Hints
FOR
ACE SARAN
PIPE & TUBING

WELDING SARAN IS EASY—Heat joints on hot plate until plastic. Then simply squeeze tightly together as shown for sound joint.



SHAPES FORMED FROM PIPE—These are typical of parts designed from corrosion-resistant, tough ACE Saran standard pipe. Similarly small-quantity parts can be formed from ACE extruded rod or special sections.



By combining pipe and tube, many complicated parts and assemblies can be formed economically with all advantages of Saran plastics by ACE.

IF IT'S MOLDED OR EXTRUDED
Specify ACE
and send your drawings to
AMERICAN HARD RUBBER COMPANY
11 MERCER STREET, NEW YORK 13, N. Y.

Redesign eliminates 12 operations, reduces Unit Cost 65 cents

ELECTROL POWERPAK: A complete hydraulic power system used for controlling flaps and landing gear in aircraft—originally confined fluid with threaded pipe plugs. Result—expensive sealing.

NEW DESIGN: Waldes Truarc rings provide positive seal up to 3000 P.S.I. for plugs without threads. Changeover eliminated two milling, ten tapping operations. Result—inexpensive sealing.

Redesign with Waldes Truarc rings not only saved us 65 cents a unit and 6¼ minutes production time, it made a more compact and finer product—reports Electrol, Inc., of Kingston, N. Y. Truarc helped cut 4 ounces a unit, eliminated milling and tapping, allowed switching from skilled to semi-skilled labor. Maintenance was cut more than a half.

Redesign with Truarc, and you will cut costs and increase production, too. Wherever you use machined shoulders, nuts, bolts, snap rings, cotter pins—there's a Truarc ring that does a better job of holding parts together. All Waldes Truarc retaining rings are precision engineered, easy to assemble and disassemble, always circular to give a never-failing grip. They can be used over and over again. Send us your problem. Waldes Truarc engineers will be glad to show how Truarc can help you.

15 Waldes Truarc Retaining Rings effect these Savings

	SAVING
• Eliminate 2 milling operations . .	$.10
• Replace 10 tapping operations with grooves	.15
• Increase accuracy of mating parts	.03
• Replace pipe plugs with plugs made in automatics	.16
• Cut plug assembly time over 50%	.15
• Reduce production test time . . .	.06
Total savings per unit . .	**$.65**

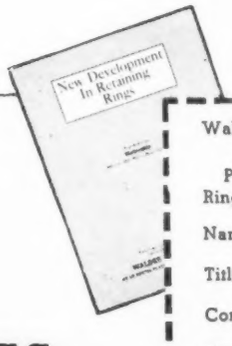
WALDES TRUARC

U. S. PATENT RE. 18,144

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

Canadian Rep.. Controlite Engineering & Sales Ltd., 20 Bloor Street W., Toronto 5



• *Send for new Truarc booklet, "New Development In Retaining Rings"*

Waldes Kohinoor, Inc., 47-10 Austel Place 28-T
Long Island City 1, N. Y.

Please send booklet, "New Development In Retaining Rings" to:

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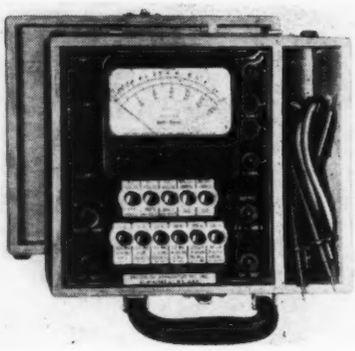
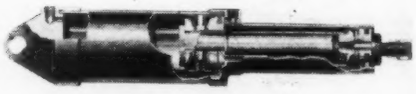


tions such as: Volts, ohms, mils, decibels, amperes, and microamperes. The other row of six buttons selects all ranges. There are 54 ranges: to 6,000 v, 600 megohms, 12 amp, 70 db and 60 microamp, 20,000 and 1,000 ohms per volt d-c and 1,000 ohms per volt alternating current.

Differential Air Engine

National Pneumatic Co., Industrial Sales Div., Rahway, N. J.

The differential principle used in these engines permits operation with either one or two controlled air lines. Positive engine powers are obtained in both directions. Operating on one controlled air line at 100 psi, Differential Engines are available in sizes to deliver "in-stroke" power ranging from 100 to 1,335 lb., and "out-stroke" power from 105 to 1,070 pounds. Each engine has a piston assembly presenting two dif-



ferent diameters. Constant air pressure from the reservoir is introduced between these pistons. The differential force is exerted towards the large end. When air is also admitted on the far side of the large piston, it will force the piston towards the small end. The double piston assembly prevents locking of the piston rod. Automatically adjusted air seals are provided by the piston cups. Air pressure against the cups causes them to expand against the cylinder walls; also compensating for wear. Engines are available with strokes of 3, 6 and 9 in., with various types of foot, hand, automatic and remote control for the air valve.

Voltage Regulator

Sorensen & Co. Inc., Stamford, Conn.

This regulator, Model E-3006, has been designed to provide a stable, regulated source of d-c voltage and current that is applicable for testing of instruments. The input voltage is carefully controlled

It's New! It's Electro-Hydraulically Controlled

THE OILGEAR "JK" VARIABLE DELIVERY FEED PUMP

For nearby or remote mounting

Small size fits space available in your machine design

Simple construction easy to service

For Machine Tool and Other Straight Line Feeds

The new Oilgear Feed Pump is a compact packaged unit designed to simplify the application of fluid power to a machine tool, process equipment or other straight line feed installation. Control is entirely electro-hydraulic, requiring only pushbuttons to be mounted on the operating side of your machine. The Feed Pump itself may be installed wherever space is available, either as part of your machine, or nearby, or remotely.

The Feed Pump is installed simply by connecting two pipes to a suitable double acting cylinder and hooking up the solenoids with pushbutton and limit switch controls.

Variable delivery pumping element, rapid traverse gear pump, solenoid operated control and relief valves are integral with the Feed Pump itself. There is *NO* mechanical control linkage . . . *NO* auxiliary pipes or valves. Valves and units can be serviced without disconnecting pipes or draining the oil reservoir.

A wide range of feed rates is provided by the new Oilgear Feed Pumps. Feed rate is established by the volume of oil delivered by the pump. Any pre-set feed rate is maintained consistently throughout the cycle, despite variations in load or changes in resistance. A new Oilgear development maintains constant feed efficiency over long periods of service. THE OILGEAR COMPANY, 1311 W. Bruce Street, Milwaukee 4, Wisconsin.

MAIL COUPON FOR NEW BULLETIN

The Oilgear Company
1311 W. Bruce St., Milwaukee 4, Wis.

Please send me a free copy of Bulletin 44110 on the new Oilgear Type "JK" Feed Pump.

*Name*_____

*Position*_____

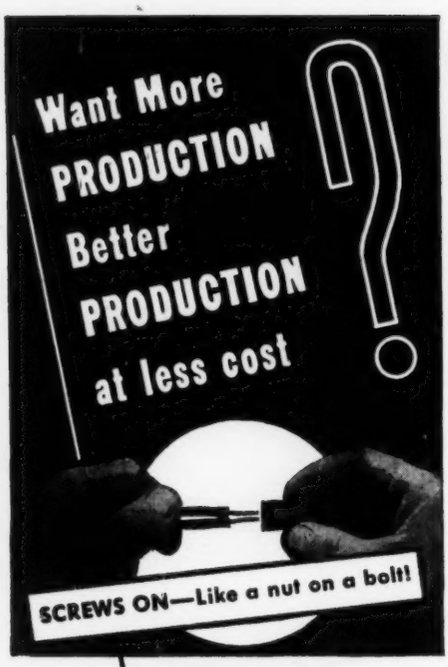
*Company*_____

*Address*_____

*City*_____ *State*_____

Oilgear Fluid Power

PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS AND VALVES



TRY **IDEAL** *Wire Nuts*®

(THE SOLDERLESS, TAPELESS WIRE CONNECTORS)
Patented—No. 1,933,555

● See for yourself how easy and economical it is to make a better, stronger, neater, safer connection of any usual combination of wires with an Ideal "Wire-Nut". . . No need to twist wire—no solder—no tape—no tools—just screw the "Wire-Nut" on the stripped wires like a nut on a bolt. Cuts material costs—speeds production—improves quality and appearance of finished product..."Wire-Nuts" are available now in sizes for wire combinations from two No. 18 through three No. 10, solid or stranded. Listed by Underwriters' Laboratories, Inc. Millions in use. Distributed through leading wholesalers. Mail coupon for *Free Samples*, Application Manual and cost data.

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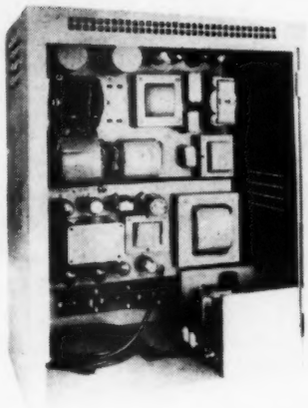
Send FREE SAMPLES of "Wire-Nuts" with application and cost data.

Name _____

Address _____

City _____ Zone _____ State _____

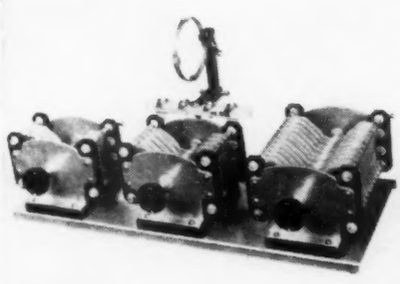


so that output is kept at its setting without variation. The upper half of this unit is a modified Nobatron with the following characteristics: Input voltage range, 95 to 125 v a-c; output voltage, 6 v d-c; load range, 7½ to 15 amp.; regulation accuracy, 0.1 percent and input frequency range of 50 to 60 cycles. The lower half contains a regulated d-c power supply with these characteristics: Input voltage range, 90 to 135 v a-c; output voltage, 0 to 300 v d-c continually adjustable; load capacity, 100 milliamp regulation accuracy 1/10 of 1 percent.

Variable Capacitors

Barker & Williamson Inc., 237 Fairchild Ave., Upper Darby, Pa.

Known as the Type JCX, these variable capacitors have stator sections to provide short r-f paths, and butterfly rotor construction that permits grounding rotor at the center of the r-f voltage point with respect to stators. Coils can be mounted directly on the capacitors for maximum efficiency. These units can be used for medium-powered triode or tetrode stage plate circuits where modulated plate voltage does not exceed 1,250 v and unmodulated plate voltage is not more than 1,500 volts. The airgap is 0.125 inches. The capacitors have stainless steel shafts and tie rods, heavy rounded aluminum plates and are available in three types: JCX-100E having a mounting length of 5½ in. and a capacity of 100 mmfd per sec-



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In *Product Engineering*, December 1946, L. L. Stott, of The Polymer Corporation, discussed moldability and machinability of this "super polymer."

A few reprints of this article are available at 10 cents each, while they last. ***Write to Reader Service Department.***

PRODUCT ENGINEERING

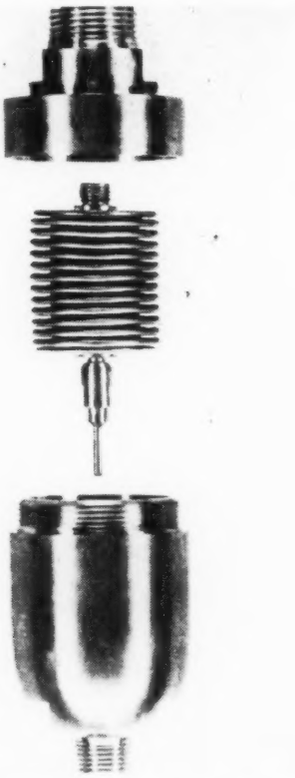
330 West 42nd St., New York 18, N. Y.

tion, JCX50E with a length of 3⅜ in. and capacity of 50 mmfd per section; and JCX25E, 2¾ in. long with a capacity of 25 mmfd per section.

High Pressure Vent Valve

Lodge & Shipley Co., Risselt Div., Cincinnati, Ohio

The functioning mechanism of the Risselt J-7 Air Eliminator is a 1½ in. 12-convolution thermostatic bellows constructed of Monel metal. This valve can cover a range of pressures up to 125 psi and is applicable to those



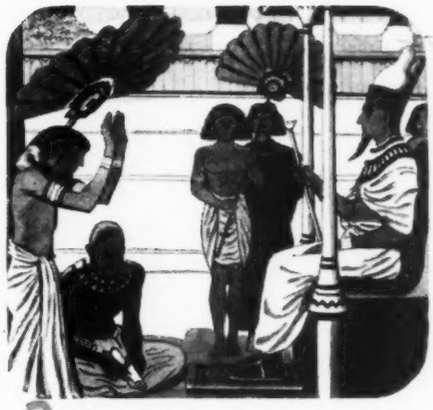
industries having high pressure heating and processing cycles. The valve seat can be replaced when necessary without replacing the whole valve. The valve case is built of 2⅛ in. brass; top and bottom completely machined. It has been used in the food, paperwood, chemical, rubber, textile and similar industries.

Metal Thickness Tester

Sperry Products Inc., 15th St. and Willow Ave., Hoboken, N. J.

With this instrument, thickness of metals and other materials can be measured where access to only one side is available. The quartz crystal searching unit of the Reflectogage is applied to the oiled surface of the material and the oscilloscope pattern is observed. A vertical deflection of the oscilloscope trace will indicate resonance of the supersonic sound beam within the material. The position of the vertical de-

1 1561—Crude, manually-operated bellows were used in an attempt to pump fresh air into a mine, but with indifferent results, according to a journal published in Switzerland. And man's quest for comfort indoors was under way.



2 1890—This age-old method of keeping cool was still in use in many parts of the world. But in this era electric motors came into general use. Soon to come were new ways to make air work for man's comfort and well-being.

3 1915—The Howell Red Band Motor made its appearance. Seven years later the first movie theater was fully air conditioned. Other businesses followed. Air conditioning was on its way, thanks to the electric motor as a source of power.

Then, Air Conditioning arrived!

4 Today it's different! And better!

Air is universally used for comfort . . . for profit. It's the exceptional business that does not put air to work.

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Why? Because Howell Motors are industrial type motors designed for the toughest applications in industry. Consequently, they perform better on all jobs.

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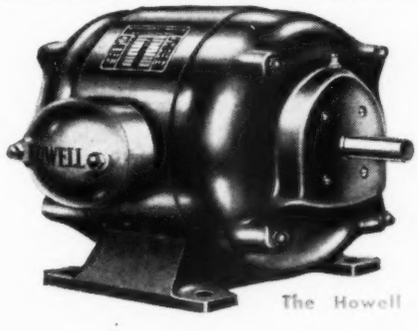
Here's another precision-built Howell Motor. Howell Motors are industrial type with copper or bronze rotors—specially insulated — statically and dynamically balanced. Be sure you specify Howells!



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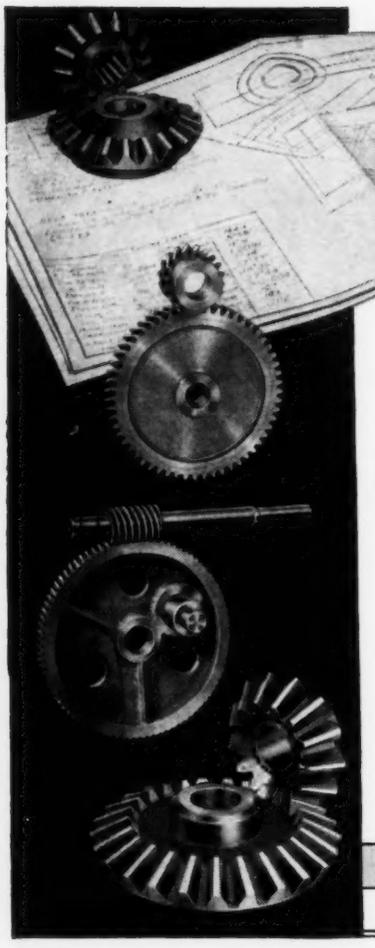

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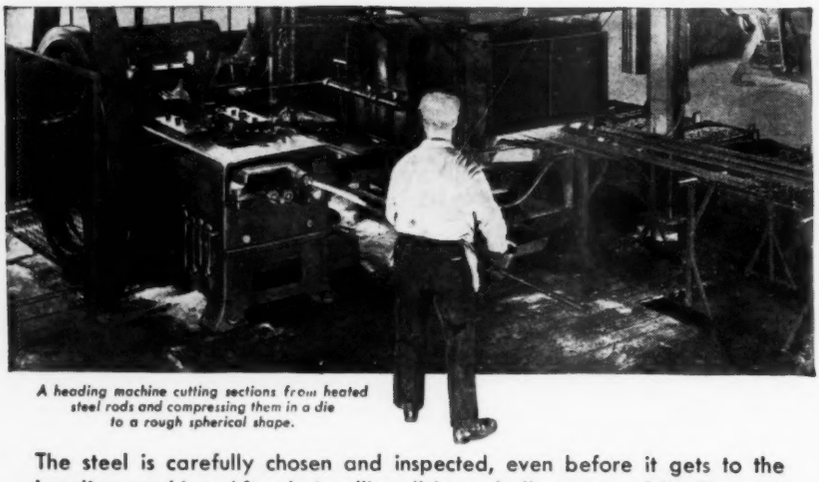

A heading machine cutting sections from heated steel rods and compressing them in a die to a rough spherical shape.

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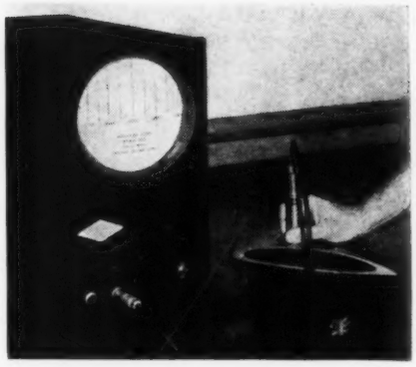

flection along the horizontal axis is determined by the resonant frequency and is thus related to thickness. A different screen is used for each type of material and for each of four thickness ranges. Thickness of tubing and flat parts, between 0.005 and 0.3 in., can be read directly from the face of the oscilloscope screen. In direct reading of the thickness of parts up to 4 in. can be done with slight calculation. Maximum error in measurement is less than 2 percent of the thickness of the material. This unit can also be used to search for internal flaws.

Portable Volt Ohmmeter

The Hickok Electrical Instrument Co., 10544 Superior Ave., Cleveland 8, Ohio

The Hickok Model 214 is a self-contained, battery operated electronic volt-ohmmeter that eliminates the need for plugging into an a-c line when testing. This instrument is suited for applications requiring resistance and voltage measurements at high impedance, 15 million ohms constant imped-

ance. The instrument is built for self-checking of the batteries, and is usable for 1,350 complete cycles of 4 min. operations. The meter is electronically protected against burn-outs. The power supply consists of two size C flashlight unit cells and one standard miniature type 45 v battery. There are six ranges each for a-c and d-c voltages, ranging from zero to 1,200 volts. Resistance can be measured from 1 ohm to 1,000 megohms in six ranges. The instrument measures 8¼ x 6 x 4¼ in. and weighs 5¼ pounds.